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# EXTRA CENSUS BULLETIN.

No. 23. WASHINGTON, D. C. September 9, 1892.

## AGRICULTURE.—IRRIGATION.

DEPARTMENT OF THE INTERIOR,
CENSUS OFFICE,
WASHINGTON, D. C., August 20, 1892.

SIR:

The accompanying report contains the summarized results of a special investigation into the condition of agriculture in the arid and subhumid states and territories, more particularly in relation to the practice of irrigation. The statistical portion of the report, which has reference mainly to the year ended May 31, 1890, is embodied in 18 tables, as follows:

1. Total number of farms in the western states and territories on which crops were raised by irrigation in 1889, area irrigated, average size of irrigated farms, and average value of farm products per acre.

2. Number of irrigated farms, area irrigated, and average size of irrigated farms in the subhumid region.

3. Percentage of entire land surface irrigated in the several states and territories in the arid region, total number of farms enumerated and percentage irrigated, and total area of land in irrigated farms and percentage of same actually irrigated.

4. States and territories in the order of the proportion of the number of farms irrigated to the total number of agricultural holdings.

5. States and territories in the order of the proportion of land irrigated to the total area of land in farms.

6. Total area of land in farms on which irrigation is practiced in the subhumid region, and percentage of same irrigated.

7. Proportion of irrigated land in cereals and forage crops to total area irrigated.

8. Total value and average value per acre on June 1, 1890, of land irrigated in arid region in 1889; total value and average value per acre of the products of irrigated land in arid region in 1889.

9. Classification of irrigated farms as under 160 acres or as 160 acres and upward, with average size of farms in each class and percentage of total.

10. Classification of large irrigated farms, as from 160 to 319 acres, from 320 to 639 acres, and 640 acres and upward, with number and average size of each class.

11. Average first cost of water right per acre, average present value of existing water rights per acre, average annual cost of water or of maintaining and repairing ditches per acre irrigated, and average first cost of preparing land for cultivation, including purchase money.

12. Total cost of productive irrigation systems, and their value in 1890.

13. First cost of irrigated lands in the arid region, including water rights, and their value in 1890.

14. Total cost of water and of maintaining and repairing ditches in 1889–1890, and total value of products of irrigated lands in 1889.

15. Average cost per mile of constructing irrigating canals and ditches.

16. Water supply of arid region, as shown by results of stream measurements.

17. Total number, average depth, average cost, and average discharge of artesian wells on farms, number used in irrigation, with total acreage irrigated and average acreage irrigated per well.

18. Total area of land irrigated and percentage of same irrigated by artesian wells.

Of the 124,808 farms enumerated in the arid region in June, 1890, 52,584, or 42.13 per cent, contained land on which crops were raised in 1889 by the artificial application of water, the entire area of land irrigated being 3,564,416 acres, 20.72 per cent of the total area of the 52,584 irrigated farms, 9.66 per cent of the total area of the whole number of farms enumerated, and about one-half of 1 per cent of the total land area of the arid region.

C. O. P.—5m

To this must be added 1,552 farms, containing 66,965 acres irrigated, in the western parts of North Dakota, South Dakota, Nebraska, Kansas, and Texas, designated, for convenience, the subhumid region, where irrigation is slowly making its way, as a method of agriculture always advantageous but not always absolutely necessary.

The average value of the land irrigated in 1889, with the improvements thereon, is found to be $83.28 per acre, and the average value of products for the year stated $14.89 per acre. By correspondence with over 20,000 irrigators, fairly distributed through the arid and subhumid regions, it has been ascertained that the average first cost of irrigation is $8.15 per acre and the average value placed upon the water rights, where separable from the land, $26.00 per acre, or over three times their original cost. The average annual expenditure for water, as distinguished from the purchase of water rights, is $1.07 per acre, and the average cost of the original preparation of the ground for cultivation, including the purchase of the land at the government rate of $1.25 per acre, is $12.12 per acre. By applying, with necessary modifications, to the enumerators' returns the averages obtained for each separate state and territory, it has been found that in round numbers the total investment in productive irrigation systems utilized in 1889, in whole or in part, was up to June 1, 1890, $29,611,000. Their value at that date was $94,412,000, showing an apparent profit of $64,801,000, or 218.84 per cent. In the same manner the aggregate first cost of the irrigated areas, with their water rights, not including the farms of the subhumid states, has been ascertained to be $77,490,000, and the value of the same on June 1, 1890, $296,850,000, showing an increase in the value of land and water rights of $219,360,000, or 283.08 per cent. In other words, the land irrigated in 1889 was worth nearly four times what it cost, no allowance evidently being made for failures. The total expenditure for water, including the maintenance and repairs of ditches, in the arid states in 1889 was $3,794,000, and the total value of products $53,057,000.

The number of artesian wells used in irrigation in the arid and subhumid regions in June, 1890, was 3,930, constructed at an average cost per well of $245.58, and giving an average discharge of 54.43 gallons per minute. The area of land thus irrigated, averaging 13.21 acres per well, amounted to 51,896 acres, or 1.43 per cent of the total area of irrigated land in the arid and subhumid regions.

This investigation has been conducted and the following bulletin prepared by Mr. Frederick Haynes Newell, special agent, under the general direction of Mr. John Hyde, special agent in charge of statistics of agriculture. Although special bulletins on irrigation in California, Colorado, and the subhumid region still remain to be published, yet, as the following report presents the more important results of the entire investigation, I take occasion to express my appreciation of the very able manner in which Mr. Newell has discharged the laborious duties devolving upon him in this connection, especially in the analysis and collocation of the immense amount of original material, both statistical and descriptive, with which he has had to deal.

Very respectfully,

ROBERT P. PORTER,
*Superintendent of Census.*

The Secretary of the Interior.

# IRRIGATION IN WESTERN UNITED STATES.

BY F. H. NEWELL.

Within the arid and subhumid regions in the western half of the United States there were irrigated in the census year ended May 31, 1890, 3,631,381 acres, or 5,674.03 square miles, approximately four-tenths of 1 per cent of the total land area west of the 100th meridian. Of this irrigated area 65.31 per cent was devoted to the raising of various kinds of forage. The total number of irrigators was 54,136, or, more correctly, this was the aggregate number of farms or agricultural holdings upon which crops were raised by means of irrigation. In this connection it may be well to note that the definition of a farm adopted for the purposes of the census includes "all considerable nurseries, orchards, and market gardens, owned by separate parties, which are cultivated for pecuniary profit and employ as much as the labor of one able-bodied workman during the year". "A farm is what is owned or leased by one man and cultivated under his care. A distant wood lot or sheep pasture, even if in another subdivision or district, is to be treated as a part of the farm, but wherever there is a resident overseer or a manager there a separate farm is to be reported." Under this classification a person can have but one farm, unless the estate is so large as to require a resident farmer upon each tract.

The average size of such portions of farms as were actually irrigated was almost exactly 67 acres. This is the result obtained by dividing the total area irrigated by the total number of holdings. This acreage is large, from the fact that in many of the states of the far west large areas of hay lands are flooded, little care or attention being bestowed upon them. This is notably the case in Nevada and Wyoming, and to a less extent in Montana and Colorado.

The average value of the products of this irrigated land was $14.89 per acre, this being the quotient obtained by dividing the total value of all products "sold, consumed, or on hand" in 1889 by the number of acres irrigated. There is an apparent tendency among farmers not only to underestimate the value of their products, especially such as are consumed on the farm, but also to overestimate the acreage irrigated. As a result the value of products per acre, obtained as above stated, is considerably less than returns popularly supposed to be obtained from irrigated lands.

The following table gives the items above mentioned for each state and territory lying within the arid region, and also for the states lying largely within the subhumid region on the east, the statistics for the latter being grouped under the designation "subhumid region":

TABLE 1.—TOTAL NUMBER, AVERAGE SIZE, ETC., OF IRRIGATED HOLDINGS.

| STATES AND TERRITORIES. | Number of irrigators in 1889. | Area irrigated in 1889, in acres. | Average size of irrigated farms, in acres, in 1889. | Average value of products per acre in 1889. |
|---|---|---|---|---|
| Total | 54,136 | 3,631,381 | 67 | $14.89 |
| Arizona | 1,075 | 65,821 | 61 | 13.92 |
| California | 13,732 | 1,004,233 | 73 | 19.00 |
| Colorada | 9,659 | 890,735 | 92 | 13.12 |
| Idaho | 4,323 | 217,005 | 50 | 12.93 |
| Montana | 3,706 | 350,582 | 95 | 12.96 |
| Nevada | 1,167 | 224,403 | 192 | 12.92 |
| New Mexico | 3,085 | 91,745 | 30 | 12.80 |
| Oregon | 3,150 | 177,944 | 56 | 13.90 |
| Utah | 9,724 | 263,473 | 27 | 18.03 |
| Washington | 1,046 | 48,799 | 47 | 17.09 |
| Wyoming | 1,917 | 229,676 | 119 | 8.25 |
| Subhumid region | 1,552 | 66,965 | 43 | |

The term "subhumid" is generally understood as applying to a portion of the Great Plains lying to the east of the arid region, and it is so used in this report upon irrigation. As a matter of course there is on the western side of the arid region a strip of country which may likewise be designated as subhumid, but this area, on account of the diversified topography of that part of the continent, is comparatively narrow and restricted, since the arid region extends on the southwest to the shores of the Pacific ocean and on the northwest to the Cascade range. For purposes of discussion the subhumid region is therefore considered as extending in a broad belt across the country from north to south and including portions of North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas. The western extremity of Texas lies far within the arid region, but since the greater part of that state is subhumid, the irrigation statistics for the entire state are placed in this category.

The following table gives for these subhumid states the principal facts relating to irrigation, namely, the number of irrigators or separate holdings, the total irrigated acreage, and the average acreage in each holding. The average value of products has not been ascertained, from the fact that in these states, where some crops were raised by irrigation while others were produced without such artificial application of water, it has been impossible to discriminate between the products raised by these two methods of agriculture. The table shows in a general way an increase from north to south, both in the number of irrigators and in the acreage irrigated, due largely to the fact that conditions of summer aridity increase with lower latitudes, but also in part to the greater density of population and the more easily available water supply toward the south.

TABLE 2.—TOTAL NUMBER, TOTAL AREA, AND AVERAGE SIZE OF IRRIGATED FARMS IN THE SUBHUMID REGION.

| STATES. | Number of irrigators in 1889. | Area irrigated in 1889, in acres. | Average size of irrigated farms, in acres, in 1889. |
|---|---|---|---|
| Total | 1,552 | 66,965 | 43 |
| North Dakota | 7 | 445 | 64 |
| South Dakota | 189 | 15,717 | 83 |
| Nebraska | 214 | 11,744 | 55 |
| Kansas | 519 | 20,818 | 40 |
| Texas | 623 | 18,241 | 29 |

The relative position of these irrigated areas, or portions of agricultural holdings upon which crops were raised by irrigation during the census year, is shown in a broad way by the first plate, the small green patches, mainly along the streams, indicating the principal places where crops were raised by the artificial application of water. In size these patches of color are not comparable among themselves, from the fact that on the scale of the map it is impossible to represent them in their true proportions, and where a number of small holdings or groups of holdings are near together they have been run into one spot, the size of which is relatively too large.

As will be seen from the map, these irrigated areas fall into a number of groups the position of which is regulated in a broad way by the topography and water supply of the country. The most prominent of these are the irrigated areas in Colorado and southeastern Wyoming, lying at the base of the foothills of the Rocky mountains. Another group is found in Utah along the Wasatch range, and a third in the great valley of California at the western base of the Sierra Nevadas.

### PERCENTAGE OF LAND SURFACE IRRIGATED.

The second plate shows the true proportion which the areas given in the first bear to the total land area of the western states and territories, both severally and collectively. In other words, these scattered green spots are brought together near the center of each state and territory and shown in true relative size, and they are further combined into one large area in the southwestern corner of the map. In the case of the states lying partly within the subhumid belt, North Dakota, South Dakota, Kansas, Nebraska, and Texas, the spots are so small as to be scarcely visible. These facts are further shown numerically in the second and third columns of Table 3, which also gives the relative number of agricultural holdings on which irrigation was practiced.

Omitting the subhumid region, in which irrigation may be considered as exceptional, the total area irrigated was 3,564,416 acres, or 5,569.40 square miles. This is almost exactly one-half of 1 per cent of the total land area of the states and territories within which irrigation is commonly practiced. In this comparison the area of 13 eastern counties of Washington and of 16 eastern counties of Oregon is taken instead of the total for the 2 states. The largest percentage by states is found in Colorado, reaching 1.34 per cent, and the smallest percentage irrigated among the arid states and territories is in Arizona, where the area is less than one-tenth of 1 per cent.

TABLE 3.—EXTENT OF IRRIGATION IN STATES AND TERRITORIES WHOLLY OR PARTIALLY WITHIN THE ARID REGION.

| STATES AND TERRITORIES. | AREA IRRIGATED. | | Total number of farms enumerated. | HOLDINGS CONTAINING IRRIGATED AREAS. | | | |
|---|---|---|---|---|---|---|---|
| | Acres. | Per cent of entire land surface of state. | | Total number. | Per cent of number of farms in state. | Total area, in acres. | Per cent of total area irrigated. |
| Total | 3,564,416 | 0.50 | 124,808 | 52,584 | 42.13 | 17,199,925 | 20.72 |
| Arizona | 65,821 | 0.09 | 1,448 | 1,075 | 74.24 | 152,345 | 43.21 |
| California | 1,004,233 | 1.01 | 53,269 | 13,732 | 25.78 | 5,622,000 | 17.86 |
| Colorado | 890,735 | 1.34 | 16,505 | 9,659 | 58.52 | 2,865,000 | 31.09 |
| Idaho | 217,005 | 0.40 | 6,654 | 4,323 | 64.97 | 832,000 | 26.08 |
| Montana | 350,582 | 0.38 | 5,664 | 3,706 | 65.43 | 1,520,853 | 23.05 |
| Nevada | 224,403 | 0.32 | 1,341 | 1,167 | 87.02 | 1,587,700 | 14.13 |
| New Mexico | 91,745 | 0.12 | 4,174 | 3,085 | 73.91 | 510,177 | 17.98 |
| Oregon (*a*) | 177,944 | 0.39 | 10,513 | 3,150 | 29.96 | 1,120,000 | 15.89 |
| Utah | 263,473 | 0.50 | 10,757 | 9,724 | 90.40 | 1,196,000 | 22.03 |
| Washington (*b*) | 48,799 | 0.23 | 11,237 | 1,046 | 9.31 | 287,000 | 17.00 |
| Wyoming | 229,676 | 0.37 | 3,246 | 1,917 | 59.06 | 1,506,850 | 15.24 |

*a* 16 eastern counties only. *b* 13 eastern counties only.

Considering the counties of these states in the order of the percentage of total area irrigated, Boulder county, Colorado, heads the list with 15.75 per cent of its entire area cultivated by means of irrigation in 1889. Next comes the county adjoining it on the south, namely, Jefferson, with 7.44 per cent. Both of these are in the vicinity of Denver, and at the eastern front of the Rocky mountains, where the water supply is unusually large and convenient. The following list gives the 10 counties containing the largest proportion of lands upon which crops were raised by irrigation in 1889:

| | PER CENT. | | PER CENT. |
|---|---|---|---|
| Boulder county, Colorado | 15.75 | Salt Lake county, Utah | 5.06 |
| Jefferson county, Colorado | 7.44 | Tulare county, California | 4.71 |
| Davis county, Utah | 6.93 | Custer county, Colorado | 4.51 |
| Orange county, California | 6.71 | Weld county, Colorado | 4.30 |
| Weber county, Utah | 5.13 | Cache county, Utah | 4.43 |

The third plate shows the proportion of the irrigated crop area in 1889 to the total area of the arid and subhumid regions, the county being taken as the unit. Five general classifications have been made, depending upon the proportion borne by the irrigated area from which crops were obtained to the total area of the county. In the first of these divisions, marked by the letter "I" on the map, the aggregate amount of irrigated land was less than two-tenths of 1 per cent of all the land in the county, including mountain and valley. The fifth division, marked on the map by the letter "V", includes all cases in which the total area of irrigated lands equaled or exceeded 2 per cent of the entire area of the county. As will be seen at a glance, the latter includes only the counties where from local peculiarities of topography the water supply is unusually abundant, and such counties as are small and contain a large proportion of irrigable land.

### PERCENTAGE OF NUMBER OF FARMS IRRIGATED.

The total number of farms enumerated in the 11 western states and territories named in Table 3 was 124,808, omitting certain western counties of Oregon and Washington. In comparison therewith it has been found that 52,584, or 42.13 per cent, of these farms contained irrigated areas; that is to say, within the arid region, or at least within the area bounded by state and county lines, and including the greater part of the arid region, irrigation is practiced upon less than one-half of the holdings, which under the census classification are designated as "farms". Of the remaining farms, on which irrigation is not practiced, by far the greater number are what are commonly known as cattle ranches, while on others crops are raised by dependence upon the rainfall.

The largest proportion of irrigated farms to the total number is found in Utah, where over nine-tenths of the agricultural holdings contain irrigated areas. The smallest proportion is in Washington, the 13 eastern counties of which, although regarded as being in part, if not wholly, within the arid region, contain relatively a small number of irrigated areas, aggregating in fact less than one-tenth of the total number of farms. Arranging the states and territories in the order of the importance of irrigation as shown by this classification, the results obtained are as given in the table on the following page.

TABLE 4.—STATES AND TERRITORIES IN THE ORDER OF THE PROPORTION OF THE NUMBER OF FARMS IRRIGATED TO THE TOTAL NUMBER OF AGRICULTURAL HOLDINGS, WITH THE PERCENTAGE OF FARMS IRRIGATED.

| | PER CENT. | | PER CENT. |
|---|---|---|---|
| 1. Utah | 90.40 | 7. Wyoming | 59.06 |
| 2. Nevada | 87.02 | 8. Colorado | 58.52 |
| 3. Arizona | 74.24 | 9. Oregon (*a*) | 29.96 |
| 4. New Mexico | 73.91 | 10. California (*b*) | 25.78 |
| 5. Montana | 65.43 | 11. Washington (*c*) | 9.31 |
| 6. Idaho | 64.97 | | |

*a* 16 eastern counties only. *b* Including the whole state. (See following paragraph.) *c* 13 eastern counties only.

Considering this table as a whole, it may be said that in the states and territories in the upper part of the list irrigation is the rule, while in those toward the foot it has less importance, and in the case of Washington it may be considered as almost exceptional. The relative position of California requires explanation, for in that state, with its enormous area and great diversity of topography, irrigation plays a peculiar part. In the northern and southern counties irrigation is practiced on a great majority of the farms, while in the counties near the center of the state, especially those bordering upon the bay of San Francisco or the Pacific ocean, it is exceptional, there being, however, but few counties in the state where it is not practiced to a greater or less extent. If the bay and coast counties, 14 in number, are deducted, California takes a position above Oregon, thus standing ninth in the list instead of tenth, with a percentage of 48.65.

### PERCENTAGE OF FARM AREA IRRIGATED.

The total area of the 52,584 agricultural holdings of each of which some portion was irrigated, as shown in Table 3, was 17,199,925 acres, or an average of 327.09 acres each. The total area irrigated was 3,564,416 acres, or 20.72 per cent of the total area of these farms. In other words, in these 11 states and territories less than half of the farms contained irrigated areas, and of this latter number one-fifth of the area was successfully irrigated. If now it is assumed that the average size of the agricultural holdings, 327.09 acres, derived as above from less than half of the farms, applies to the whole 124,808, the total area of these farms would be 40,823,449 acres.

In comparison with this total farm area of 40,823,449 acres, the 3,564,416 acres of irrigated land evidently form only 8.73 per cent of the land owned by farmers within the states and territories designated. This is a significant fact, especially in relation to the water supply, for it has been found upon a detailed examination of each county and locality that as a rule the greater part if not all of the easily available water supply has been utilized, and in 1888 and 1889 the losses through drought were enormous, yet less than one-tenth of the land belonging to the farmers actually produced a crop by means of irrigation. It must be borne in mind, however, that a portion of the remaining nine-tenths, especially in the state of California, does not require irrigation, and that a still larger portion is unquestionably above the reach of water; but from a careful consideration of these figures it would seem as if the whole of the water supply of the arid region must be needed to irrigate properly the lands already owned by farmers and not yet fully utilized, provided that these lands are so situated as to be susceptible of irrigation.

Comparing the states and territories among themselves as regards the completeness of the irrigation of the area of the farms which are wholly or in part cultivated in this manner, it is seen that Arizona stands at the head, with a percentage of 43.21, while Nevada comes last, with only 14.13 per cent of the area of each farm irrigated. Arranging these in the order of this relation, the following result is obtained:

TABLE 5.—STATES AND TERRITORIES IN THE ORDER OF THE PROPORTION OF LAND IRRIGATED TO THE TOTAL AREA OF LAND IN FARMS. (*a*)

| | PER CENT. | | PER CENT. |
|---|---|---|---|
| 1. Arizona | 43.21 | 7. California | 17.86 |
| 2. Colorado | 31.09 | 8. Washington | 17.00 |
| 3. Idaho | 26.08 | 9. Oregon | 15.89 |
| 4. Montana | 23.05 | 10. Wyoming | 15.24 |
| 5. Utah | 22.03 | 11. Nevada | 14.13 |
| 6. New Mexico | 17.98 | | |

*a* This table, as stated above, applies only to farms upon which irrigation is practiced in part at least, and not to all the farms of the state or territory.

In Wyoming and Nevada the agricultural holdings are as a rule very large, being used chiefly for stock raising. As might be expected, therefore, the irrigated portions constitute but a small percentage of the whole area. Thus, although irrigation is essential, these states are found near the foot of the list.

In the case of the subhumid states any comparison of the area irrigated with the total area of the state would have little value, from the fact that irrigation is exceptional and is practiced in widely scattered localities. The following table, however, shows the relation between the irrigated area and the total area of the agricultural holdings on which this method of agriculture is practiced. Taking the five subhumid states as a whole, only 6.40 per cent of the farms owned by men who practiced irrigation is actually cultivated in this manner. In comparing the percentages for the states, it will be seen that they diminish in order from north to south, ranging from 34.77 in North Dakota, the highest, to 2.43 in Texas, the lowest. The small percentage in the latter state is partly due to the fact that irrigation is largely carried on by means of water from springs or wells, small areas of garden, fruit and shade trees, and of forage crops being watered on each farm, even where field crops are raised by dependence upon rainfall.

TABLE 6.—TOTAL AREA OF LAND IN FARMS ON WHICH IRRIGATION IS PRACTICED IN SUBHUMID REGION, AND PERCENTAGE OF SAME IRRIGATED.

| STATES. | Total area, in acres. | Area irrigated in 1889, in acres. | Per cent irrigated. |
|---|---|---|---|
| Total | 1,045,993 | 66,965 | 6.40 |
| North Dakota | 1,280 | 445 | 34.77 |
| South Dakota | 52,466 | 15,717 | 29.96 |
| Nebraska | 81,305 | 11,744 | 14.44 |
| Kansas | 161,020 | 20,818 | 12.93 |
| Texas | 749,922 | 18,241 | 2.43 |

CHARACTER OF CROPS.

The character of the crops raised by irrigation is shown in a broad way in Table 7, in which a classification is made into two great groups, cereals on the one hand and forage crops and miscellaneous products on the other, of this latter group the forage forming the greater part. From this table it appears that over one-third of the area irrigated was devoted to cereals, viz, to wheat, oats, Indian corn, barley, rye, and buckwheat, the importance of these products being in the order named. Of the remainder of the crop probably 60 per cent or over consisted of forage, including the various grasses and clovers, alfalfa or lucern, and also wheat, oats, corn, and other cereal plants cut before maturity for the purpose of feeding cattle. The irrigated fruit crops of California will be dealt with in the bulletin on irrigation in that state.

Only four-tenths of the area irrigated was utilized for the production of small grains and of the various kinds of vegetables and fruits produced within the arid region. In this connection it should be stated that this investigation of the statistics of irrigation has had to deal with the total acreages and values of crops irrigated, the figures showing the amount of the different products and the value of the same being a part of the general agricultural census and not of this special branch. By obtaining in round numbers, however, the cereal production of the arid region it has been possible to approximate the character of the crop, as shown in Table 7. In many cases it is impossible to draw the line sharply between the plants raised by irrigation and those not watered in the census year, from the fact that in many localities farmers were successful to a greater or less degree in cultivating a part of their land without applying water, even in localities within what is known as the arid region.

TABLE 7.—GENERAL CHARACTER OF IRRIGATED CROPS.

| STATES AND TERRITORIES. | Total acreage irrigated in 1889. | FORAGE, ETC. | | CEREALS. | |
|---|---|---|---|---|---|
| | | Per cent. | Acres. | Per cent. | Acres. |
| Total | 3,564,416 | 65.31 | 2,328,016 | 34.69 | 1,236,400 |
| Arizona | 65,821 | 65.82 | 43,321 | 34.18 | 22,500 |
| California | 1,004,233 | 47.22 | 474,233 | 52.78 | 530,000 |
| Colorado | 890,735 | 70.25 | 625,735 | 29.75 | 265,000 |
| Idaho | 217,005 | 70.97 | 154,005 | 29.03 | 63,000 |
| Montana | 350,582 | 78.61 | 275,582 | 21.39 | 75,000 |
| Nevada | 224,403 | 93.32 | 209,403 | 6.68 | 15,000 |
| New Mexico | 91,745 | 36.78 | 33,745 | 63.22 | 58,000 |
| Oregon | 177,944 | 69.99 | 124,544 | 30.01 | 53,400 |
| Utah | 263,473 | 56.35 | 148,473 | 43.65 | 115,000 |
| Washington | 48,799 | 57.99 | 28,299 | 42.01 | 20,500 |
| Wyoming | 229,676 | 91.73 | 210,676 | 8.27 | 19,000 |

VALUE OF LAND AND CROPS.

The average value in 1890 of the land upon which crops were raised by irrigation in 1889 and the average value of the products per acre in 1889 are shown in Table 8, these averages being obtained by dividing total values by the number of acres for which values were given; that is to say, in cases where the returns of farm values of products were deficient the acreage was omitted in order to obtain the averages, it being assumed that these few cases did not differ materially from the mean of all others. For the 11 states and territories given, the average value of the irrigated land, including improvements, such as fences and buildings, was $83.28 per acre, ranging from $31.40 per acre, in the case of Wyoming, up to $150.00 per acre, in that of California. The total value of this irrigated land and its improvements thus obtained was $296,850,000.

The average value of products for the 11 states, $14.89 per acre (to nearest figure), multiplied into the number of acres gives in round numbers a total of $53,057,000. This average value has been obtained, as above stated, by taking all the cases in which definite returns were made and assuming that they represent the general condition, since they include from 95 to over 99 per cent of the agricultural holdings of each state. In the case of the states and territories where crops are raised on the same farm both with and without irrigation it is exceedingly difficult and not unfrequently impossible to discriminate between them.

TABLE 8.—VALUE OF IRRIGATED LANDS IN ARID REGION IN 1890 AND OF THEIR PRODUCTS IN 1889.

| STATES AND TERRITORIES. | Area irrigated in 1889, in acres. | VALUE OF FARMS ON JUNE 1, 1890. | | VALUE OF PRODUCTS IN 1889. | |
|---|---|---|---|---|---|
| | | Average value per acre. | Total value. | Average value per acre. | Total value. |
| Total | 3,564,416 | $83.28 | $296,850,000 | $14.89 | $53,057,000 |
| Arizona | 65,821 | 48.68 | 3,204,000 | 13.92 | 916,000 |
| California | 1,004,233 | 150.00 | 150,635,000 | 19.00 | 19,080,000 |
| Colorado | 890,735 | 67.02 | 59,696,000 | 13.12 | 11,686,000 |
| Idaho | 217,005 | 46.50 | 10,091,000 | 12.93 | 2,806,000 |
| Montana | 350,582 | 49.50 | 17,354,000 | 12.96 | 4,544,000 |
| Nevada | 224,403 | 41.00 | 9,200,000 | 12.92 | 2,899,000 |
| New Mexico | 91,745 | 50.98 | 4,677,000 | 12.80 | 1,174,000 |
| Oregon | 177,944 | 57.00 | 10,143,000 | 13.90 | 2,473,000 |
| Utah | 263,473 | 84.25 | 22,198,000 | 18.03 | 4,750,000 |
| Washington | 48,799 | 50.00 | 2,440,000 | 17.09 | 834,000 |
| Wyoming | 229,676 | 31.40 | 7,212,000 | 8.25 | 1,895,000 |

SIZE OF FARMS.

The average size of farms is shown in the fourth plate, which gives at a glance the localities where the farms, or rather portions of farms, on which crops were raised by irrigation are large or small, the county being taken as the basis for representation. The fact brought out most prominently by this map is the large size of the areas devoted mainly to the raising of forage crops, as in Nevada, Montana, and Wyoming. On the other hand, where irrigation is highly advanced and the products are of more than usual value the irrigated holdings are small. The condition of the water supply, however, and the density of settlement often come in to modify this generalization, the irrigated areas being large where water is abundant and the population is scattered.

In order to examine into the average size of the majority of irrigated areas and to eliminate the results produced by the existence of large tracts of land owned by a few men, Table 9 has been prepared, in which the irrigated holdings have been classified according to size. The larger areas have been taken out and placed by themselves, thus allowing the far greater number of moderate sized holdings to be considered independently. For this classification 160 acres, or a quarter section, has been taken as the basis, and for simplicity all irrigated holdings or parts of holdings under 160 acres in area are called "small farms", and those of 160 acres or over are designated as "large farms", it being understood that these terms apply only to the areas irrigated, and not to the total holding of each individual, so that if a farmer owns 640 acres and irrigates 40 acres, the latter number is the one considered and it is classed as a small farm.

Out of the 54,136 holdings upon which crops were raised by irrigation in the census year there were 4,595 in which the area irrigated was 160 acres or upward, the total of the same being 1,802,605 acres, or 49.64 per cent of the whole amount irrigated; that is to say, 4,595 persons, or 8.49 per cent of those irrigating, owned very nearly one-half of the total area irrigated. The great majority of irrigators, 91.51 per cent, irrigated 1,828,776 acres, or an average of nearly 37 acres each, against an average of 392 acres upon which crops were raised by irrigation by the few large owners.

TABLE 9.—RELATIVE NUMBER AND SIZE OF IRRIGATED FARMS.

| STATES AND TERRITORIES. | UNDER 160 ACRES. | | | | 160 ACRES AND UPWARD. | | | |
|---|---|---|---|---|---|---|---|---|
| | Number. | Total irrigated area, in acres. | Average size, in acres. | Per cent of total. | Number. | Total irrigated area, in acres. | Average size, in acres. | Per cent of total. |
| Total | 49,541 | 1,828,776 | 37 | 50.36 | 4,595 | 1,802,605 | 392 | 49.64 |
| Arizona | 996 | 43,165 | 43 | 65.58 | 79 | 22,656 | 287 | 34.42 |
| California | 12,595 | 382,850 | 30 | 38.12 | 1,137 | 621,383 | 547 | 61.88 |
| Colorado | 8,227 | 451,215 | 55 | 50.66 | 1,432 | 439,520 | 307 | 49.34 |
| Idaho | 4,110 | 159,528 | 39 | 73.51 | 213 | 57,477 | 270 | 26.49 |
| Montana | 3,130 | 174,009 | 56 | 49.63 | 576 | 176,573 | 307 | 50.37 |
| Nevada | 823 | 47,812 | 58 | 21.31 | 344 | 176,591 | 513 | 78.69 |
| New Mexico | 3,022 | 72,069 | 24 | 78.55 | 63 | 19,676 | 312 | 21.45 |
| Oregon | 2,896 | 101,788 | 35 | 57.20 | 254 | 76,156 | 300 | 42.80 |
| Utah | 9,641 | 237,616 | 25 | 90.19 | 83 | 25,857 | 312 | 9.81 |
| Washington | 994 | 31,943 | 32 | 65.46 | 52 | 16,856 | 324 | 34.54 |
| Wyoming | 1,614 | 79,962 | 50 | 34.82 | 303 | 149,714 | 494 | 65.18 |
| Subhumid region | 1,493 | 46,819 | 31 | 69.92 | 59 | 20,146 | 341 | 30.08 |

All the cases in which 160 acres or upward of crop were irrigated have been tabulated (see Table 10) under three headings, viz, those of from 160 to 319 acres, those of from 320 to 639 acres, and those of 640 acres and upward, these figures, as before stated, applying not to the total acreage of the agricultural holding, but only to that portion upon which crops were raised by the artificial application of water.

Taking the irrigated areas of 640 acres or upward, Table 10 shows that they numbered 411, with an aggregate area of 724,147 acres, or an average of 1,762 acres each. The 411 individuals or corporations owning these irrigated lands constituted three-fourths of 1 per cent (0.76) of the number of irrigators and held 19.94 per cent of the total area.

TABLE 10.—RELATIVE NUMBER AND SIZE OF LARGE IRRIGATED FARMS.

| STATES AND TERRITORIES. | 160 TO 319 ACRES. | | | 320 TO 639 ACRES. | | | 640 ACRES AND OVER. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number. | Total irrigated area, in acres. | Average size, in acres. | Number. | Total irrigated area, in acres. | Average size, in acres. | Number. | Total irrigated area, in acres. | Average size, in acres. |
| Total | 3,242 | 671,151 | 207 | 942 | 407,307 | 432 | 411 | 724,147 | 1,762 |
| Arizona | 57 | 10,454 | 183 | 15 | 6,515 | 434 | 7 | 5,687 | 812 |
| California | 738 | 152,542 | 207 | 243 | 103,488 | 426 | 156 | 365,353 | 2,342 |
| Colorado | 1,113 | 224,518 | 202 | 244 | 103,845 | 426 | 75 | 111,157 | 1,482 |
| Idaho | 172 | 34,751 | 202 | 34 | 14,036 | 413 | 7 | 8,690 | 1,241 |
| Montana | 421 | 88,994 | 211 | 123 | 51,986 | 423 | 32 | 35,593 | 1,112 |
| Nevada | 201 | 46,556 | 232 | 91 | 41,494 | 456 | 52 | 88,541 | 1,703 |
| New Mexico | 46 | 10,202 | 222 | 14 | 6,460 | 461 | 3 | 3,014 | 1,005 |
| Oregon | 192 | 38,736 | 202 | 49 | 21,110 | 431 | 13 | 16,310 | 1,255 |
| Utah | 65 | 13,234 | 204 | 13 | 5,555 | 427 | 5 | 7,068 | 1,414 |
| Washington | 36 | 7,599 | 211 | 11 | 4,615 | 420 | 5 | 4,642 | 928 |
| Wyoming | 161 | 35,370 | 220 | 93 | 42,780 | 460 | 49 | 71,564 | 1,460 |
| Subhumid region | 40 | 8,195 | 205 | 12 | 5,423 | 452 | 7 | 6,528 | 933 |

COST OF IRRIGATION.

The statistics concerning the acreage and value of land and products have been taken from the enumerators' returns for each agricultural holding. Other facts now to be discussed have been obtained by direct correspondence with farmers by means of special schedules addressed to each irrigator. These schedules contained questions intended to cover facts concerning the location of irrigated land, the character of the water supply, the cost of irrigation, methods of using the water, necessity of irrigation, the use of artesian wells and pumps; also the location of canals or irrigating ditches, size and cost, methods of distributing the water, etc. In all about 30,000 replies have been received, and from these, after proper tabulation, certain averages have been drawn, the principal of which are shown in Table 11.

The average first cost of bringing water to the land throughout the entire arid and subhumid regions has been $8.15 per acre. This average is derived from the statements of all persons who have constructed ditches or have purchased water rights from others. It includes all cases from those, on the one hand, where the farmers have dug

or plowed small ditches leading from the river or creek to their land, to those, on the other, where the irrigator purchased the right to take water from some large canal, and embraces all the intermediate conditions where water was obtained through co-operation of neighboring land owners or through partnerships of farmers. The fact that a person has used water upon a certain number of acres entitles him in many localities to certain rights or privileges, and therefore it has become customary to term property of this kind a "water right", and the first cost of applying the water to the land can be considered as the cost of this "water right".

In the different states and territories there is a wide range in this average first cost of applying water to the land, or of the water right. The highest average is in the case of California, where the most thorough and expensive systems for saving and distributing water have been constructed; the lowest is in the case of Wyoming, where enormous areas have been covered with water by means of ditches quickly and cheaply constructed by means of plow and scraper, the average cost in this latter state being little more than one-fourth of that given for California.

The average value per acre of these water rights, wherever they can be considered independently of the value of the land, is $26.00. This is the average of the values given to this privilege or property by the owners of water rights or of independent ditches. In many localities, however, owing to scarcity of water or to other causes, the water right can not be taken from the land without depriving the latter of its entire value, for without a water supply the land is worthless. In such cases the entire value inheres in the water right, and if it is assumed that the average value of the land is $83.28 per acre, at least $80.00 of this, and possibly more, must be attributed to the water right. Taking, however, those cases in which water rights are transferable and are sold or treated like other pieces of property, the apparent profit to the creator of these rights has been the difference between $26.00 and $8.15, or $17.85 per acre.

Besides the first cost of water, viz, the expense of constructing ditches from the stream or the cost of shares in some irrigating canal, the irrigator must pay a small amount annually or must expend some labor in order to repair the ditches and keep them in good order, the amount being often only a few cents per acre. Where he takes water from some larger canal, especially one owned by a corporation, he may be compelled to pay a larger sum, that will not only cover the cost of keeping the canal in repair, but will also pay interest on the investment, salaries of officers, and other items of expense. In the aggregate this often amounts to from $2.00 to $3.00 or even more per acre. Averaging, however, all the statements as to the annual cost of water, the result for the entire arid and subhumid regions is $1.07 per acre.

Since the greater part of the irrigators own the small ditches used for bringing water from the streams to the land, having built such ditches at points where the conditions are most favorable for construction and maintenance, the annual cost of keeping them in repair is undoubtedly small, much less than it would be under other conditions. For example, with the construction of larger irrigating works designed to carry water to land farther away from the streams and to overcome more or less serious obstacles, the first cost of irrigation is usually greater, as is also the annual cost, on account of the heavy interest upon the original investment, and also from the fact that salaries and other items of expense which do not enter into the operation of the small ditches must be included.

The average cost of bringing the land under cultivation beyond the expense for water, but including fencing, etc., was, according to the statements of the farmers, $12.12 per acre, ranging from $4.62 per acre, in the case of the subhumid states, to $17.48 per acre, in California, the difference being due both to the configuration and character of the ground and to the amount of labor spent in preparing it for the various kinds of crops. For example, in most of the states where the cost of cultivation is low the ground originally was nearly barren, and there were no plants, except perhaps sagebrush, to be removed.

In cases where the expense of preparing the ground for cultivation was great, either the ground was rough and uneven, requiring more or less leveling in order that the water might be applied economically, or it was covered with willows and other small trees, requiring considerable labor before the fields could be brought into arable condition. Also where fruit trees and vines were to be planted great expense has often been incurred, especially in California.

TABLE 11.—AVERAGE COST OF IRRIGATION, CULTIVATION, ETC.

| STATES AND TERRITORIES. | Average first cost of water rights per acre. | Average value of water rights per acre in 1890. | Average annual cost of water per acre. | Average first cost of cultivation per acre. |
|---|---|---|---|---|
| Total | $8.15 | $26.00 | $1.07 | $12.12 |
| Arizona | 7.07 | 12.58 | 1.55 | 8.60 |
| California | 12.95 | 39.28 | 1.60 | 17.48 |
| Colorado | 7.15 | 28.46 | 0.79 | 9.72 |
| Idaho | 4.74 | 13.18 | 0.80 | 9.31 |
| Montana | 4.63 | 15.04 | 0.95 | 8.29 |
| Nevada | 7.58 | 24.60 | 0.84 | 10.57 |
| New Mexico | 5.58 | 18.30 | 1.54 | 11.71 |
| Oregon | 4.64 | 15.48 | 0.94 | 12.59 |
| Utah | 10.55 | 26.84 | 0.91 | 14.85 |
| Washington | 4.03 | 13.15 | 0.75 | 10.27 |
| Wyoming | 3.62 | 8.69 | 0.44 | 8.23 |
| Subhumid region | 4.07 | 14.81 | 1.21 | 4.62 |

TOTAL INVESTMENT AND PROFITS.

By making use of the averages given in Table 11 and applying them, with proper modifications, to the total acreages given in Table 1, it is possible to arrive at certain conclusions as to the amount invested in irrigation works and in lands cultivated by irrigation, also as to the value of the same and the increased value or profit realized by the owners of lands and water rights. The results obtained are shown in round numbers in Tables 12, 13, and 14. In the cases of Nevada and Wyoming a mean value has been substituted for the average first cost of water for each state, shown in Table 11, from the fact that, as stated in previous bulletins, the average first cost of bringing water to the land in Nevada, owing to peculiar circumstances, applied to the land which was under a comparatively high state of cultivation, and not to the hay lands, while in Wyoming the reverse was the case.

In Table 12, under the head of "Cost", is given the total first cost of bringing water to the land irrigated during the census year; that is to say, this is in round numbers the sum of the amounts obtained by multiplying the acreage given in Table 1 by the average first cost of obtaining water, or of water rights, as given in the statements of irrigators. It may also be considered as the investment in time and money in the construction of irrigating systems in use during the census year, under the broad assumption that each system was employed to its full capacity. In such cases, however, as those in which a canal furnished water to only a small proportion of the irrigable lands only a portion of the total cost of the canal would be represented in the totals shown.

The total first cost of irrigating the designated land was for the entire arid and subhumid regions $29,611,000, this being the amount, as stated above, presumably invested in productive irrigation works. The total value of the works or of the rights thus created, assuming that the statements of the farmers apply to all cases, was $94,412,000, showing an apparent increase or profit of $64,801,000, or 218.84 per cent. As to the total cost of the irrigation works or the expenditures for irrigation upon lands which for one reason or another were unproductive it is impossible to obtain reliable estimates. Statements and conjectures have been made by interested parties, but they have no foundation so far as can be ascertained beyond the personal impressions of the individuals making the statements.

TABLE 12.—TOTAL APPROXIMATE COST OF PRODUCTIVE IRRIGATION SYSTEMS AND THEIR VALUE IN 1890.

| STATES AND TERRITORIES. | Cost. | Value in 1890. | Increase. |
|---|---|---|---|
| Total | $29,611,000 | $94,412,000 | $64,801,000 |
| Arizona | 465,000 | 828,000 | 363,000 |
| California | 13,005,000 | 39,446,000 | 26,441,000 |
| Colorado | 6,369,000 | 25,350,000 | 18,981,000 |
| Idaho | 1,029,000 | 2,860,000 | 1,831,000 |
| Montana | 1,623,000 | 5,273,000 | 3,650,000 |
| Nevada | 1,251,000 | 3,714,000 | 2,463,000 |
| New Mexico | 512,000 | 1,679,000 | 1,167,000 |
| Oregon | 826,000 | 2,755,000 | 1,929,000 |
| Utah | 2,780,000 | 7,072,000 | 4,292,000 |
| Washington | 197,000 | 642,000 | 445,000 |
| Wyoming | 1,281,000 | 3,801,000 | 2,520,000 |
| Subhumid region | 273,000 | 992,000 | 719,000 |

The results shown in the foregoing table apply to irrigation constructions or rights considered apart from the land. As a matter of fact, in the vast majority of cases it is practically impossible to separate land values in the arid region and assign to them a certain sum, for the value of the land is inseparably bound up with the question of water supply.

In considering what may have been the first cost of the irrigated land upon which crops were raised in the census year it is necessary to assume a sum representing the purchase price of the wild or desert land, the cost of bringing water to the land, and that of cultivating the soil, building fences, and performing other necessary operations. Table 13 gives in round numbers the acreage under discussion multiplied by the probable first cost of these 3 items per acre, as shown in part in Table 11. It also shows the total value of this same land, as given in Table 8, and the difference or increase in value, or, in other words, the profit to the farmer or owner of these irrigated areas. From the table it appears that the total first cost of this land, excluding the subhumid states, was $77,490,000, and the value, as derived from the statements of a majority of the owners, was $296,850,000, showing an increase of $219,360,000, or 283.08 per cent.

TABLE **13.**—FIRST COST OF IRRIGATED AREAS, INCLUDING WATER RIGHTS, AND THEIR VALUE IN 1890.

| STATES AND TERRITORIES. | First cost. | Value on June 1, 1890. | Increase. |
|---|---|---|---|
| Total | $77,490,000 | $296,850,000 | $219,360,000 |
| Arizona | 1,114,000 | 3,204,000 | 2,090,000 |
| California | 31,814,000 | 150,635,000 | 118,821,000 |
| Colorado | 16,140,000 | 59,696,000 | 43,556,000 |
| Idaho | 3,320,000 | 10,091,000 | 6,771,000 |
| Montana | 4,968,000 | 17,354,000 | 12,386,000 |
| Nevada | 3,905,000 | 9,200,000 | 5,295,000 |
| New Mexico | 1,701,000 | 4,677,000 | 2,976,000 |
| Oregon | 3,288,000 | 10,143,000 | 6,855,000 |
| Utah | 7,022,000 | 22,198,000 | 15,176,000 |
| Washington | 759,000 | 2,440,000 | 1,681,000 |
| Wyoming | 3,459,000 | 7,212,000 | 3,753,000 |

The total amount expended each year in maintaining systems of irrigation may be assumed, for purposes of comparison, to be represented by the total acreage of Table 1 multiplied by the average expenditure per acre as reported by the irrigators (Table 11). This is given in round numbers in the table below, and the total value of products as shown in Table 8 is placed in comparison with it. The difference represents the net value of products from the irrigated land, or the sum by which the irrigator must reimburse himself for his labor and for interest on the capital invested. This table shows that $3,794,000 was the probable amount expended during the census year at least for maintenance of canals and ditches, or 12.81 per cent of the amount previously assumed as the first cost of these systems. The average value of the products, deducting the cost of water for the year, viz, $49,263,000, represents a return of 16.60 per cent upon the total value of the land with its water rights.

TABLE **14.**—TOTAL COST OF WATER AND OF MAINTAINING DITCHES IN 1889–1890, AND TOTAL VALUE OF PRODUCTS OF IRRIGATED LANDS IN 1889.

| STATES AND TERRITORIES. | Total cost of water. | Value of products. | Difference. |
|---|---|---|---|
| Total | $3,794,000 | $53,057,000 | $49,263,000 |
| Arizona | 102,000 | 916,000 | 814,000 |
| California | 1,607,000 | 19,080,000 | 17,473,000 |
| Colorado | 704,000 | 11,686,000 | 10,982,000 |
| Idaho | 174,000 | 2,806,000 | 2,632,000 |
| Montana | 333,000 | 4,544,000 | 4,211,000 |
| Nevada | 188,000 | 2,899,000 | 2,711,000 |
| New Mexico | 141,000 | 1,174,000 | 1,033,000 |
| Oregon | 167,000 | 2,473,000 | 2,306,000 |
| Utah | 240,000 | 4,750,000 | 4,510,000 |
| Washington | 37,000 | 834,000 | 797,000 |
| Wyoming | 101,000 | 1,895,000 | 1,794,000 |

COST OF IRRIGATING CANALS.

Classifying irrigating canals and ditches according to their widths, it has been found that for those averaging less than 5 feet in width the expense of construction, including headworks, flumes, etc., was $481 per mile; for those 5 feet in width and under 10 feet, $1,628 per mile, and for those 10 feet or more in width, $5,603 per mile. The greater number of the irrigating systems of the country have been constructed under such conditions that the owners can not give even an approximate estimate as to what they really cost. Many of them have been built by the efforts of a few farmers acting originally in partnership, and have been enlarged from year to year as more land was brought under cultivation and population increased. Farmers as a rule do not keep account of the amount of labor or money expended on such works, and in cases where they own the irrigating ditches they do not take into consideration the labor expended upon the ditches at times when the farm work is not pressing.

Table 15 shows the average cost per mile of the 3 classes of irrigation works for each state and territory, and exhibits the variations in cost due to difference in topography, thoroughness in construction, and accidental circumstances. California heads the list as to cost, standing far in advance of the other political divisions of the country in this regard, as well as in other items already given. The differences in cost are also due largely to the condition of development of irrigation, the states where the methods are crude and simple generally showing a less average expenditure, although the existence of one or two great works has introduced apparent departures from this rule.

TABLE 15.—AVERAGE COST PER MILE OF CONSTRUCTING IRRIGATING CANALS AND DITCHES.

| STATES AND TERRITORIES. | Under 5 feet in width. | 5 to 10 feet in width. | 10 feet and over in width. |
|---|---|---|---|
| General average | $481 | $1,628 | $5,603 |
| Arizona | 471 | 1,674 | 5,274 |
| California | 885 | 5,957 | 15,511 |
| Colorado | 380 | 1,131 | 5,258 |
| Idaho | 205 | 810 | 1,320 |
| Montana | 325 | 800 | 2,300 |
| Nevada | 200 | 1,150 | ..... |
| New Mexico | 310 | 581 | 6,666 |
| Oregon | 260 | 1,060 | 1,300 |
| Utah | 493 | 1,025 | 3,072 |
| Washington | 285 | 1,236 | 2,571 |
| Wyoming | ..... | 837 | 3,884 |
| Subhumid region | 303 | 447 | 1,884 |

WATER SUPPLY.

Facts concerning the water supply for irrigation have been ascertained in a general way by correspondence with irrigators and owners of canals and ditches, mainly by means of special irrigation schedules sent to all parts of the west. Obviously it is not possible in this way to obtain exact statements, for data as to the amount of water available or utilized for irrigation can be obtained only by means of measurements made by engineers skilled in such matters. The average irrigator has very indefinite notions concerning the amount of water flowing in streams, especially in those of considerable size, and in fact it is almost impossible for any person who has not made a specialty of such matters even to approximate such quantities with success.

As a general statement, it may be said that throughout the arid region there is hardly a stream of small size from which water can be conducted readily upon arable land that has not been utilized to its full capacity during the summer season. To increase the area under irrigation it will be necessary either to use greater economy in employing the water, so that it will cover larger areas, or to store the flood and waste waters of the nonirrigating season. A great increase in the acreage cultivated can come also by the construction of expensive works to divert the water of large rivers upon lands which can not be watered except by the expenditure of a large amount of capital. Taking the country as a whole, there are very few localities, if any, where, as in the past, a farmer can divert water unclaimed by others and by means of a simple ditch constructed by himself and his neighbors bring his farm under irrigation.

From the replies of irrigators throughout the country it is apparent that in 1888 and 1889 there was a deficiency of water supply for the land then under cultivation along most of the streams. By a comparison of all the facts it is evident that, taking the past decade as a whole, there was an unusually large amount of water in the streams in 1885 and 1886, and that this amount decreased year by year, although by no means constantly in all localities. Thus it happened that while the area under irrigation was rapidly increasing, the water supply as a whole

decreased, and during the years of drought, viz, 1888 and 1889, and in some localities 1890, there was general loss of crops upon irrigated lands, due to the fact that a larger acreage was tilled than could be irrigated by the methods in use.

Not only was there loss of crops in many counties, but the areas which were irrigated and from which crops were obtained did not in many instances receive a sufficient amount of water to produce large or satisfactory results. Many statements have been made that, owing to insufficiency of water during the latter part of the season, some of the cereal plants were cut for forage or were hardly worth the gathering.

The simple fact that the area which can be irrigated is dependent upon the amount of water flowing in the streams is often ignored in general discussions of irrigation and its possibilities. It is often taken for granted that because there are vast areas of fertile land along some river, some of which has been irrigated profitably, larger and larger areas will, with the progress of settlement, be brought under cultivation to an indefinite extent, the assumption being tacitly made that since the river drains a large area its waters must be proportionately abundant. It is unfortunately the case, however, that many of the rivers of the arid region occupying a prominent place upon the map carry a very small amount of water for a part of the year, and this water is all utilized or needed for the land now wholly or in part under cultivation.

In order to ascertain the extent of the water supply, and consequently the area irrigable, it will be necessary to measure the amount of water flowing in a number of streams in all parts of the country, and to continue these measurements for a length of time sufficiently great to obtain the amount and character of the fluctuations of typical rivers and creeks. Work of this character has already been attempted by the state engineers of California and Colorado, and on an extended scale by the United States Geological Survey. The results of many of these stream measurements are given in Table 16, which exhibits in the most condensed form possible the present condition of knowledge regarding the streams of the arid region, reference being given to reports where more detailed statements can be found.

This table (No. 16) gives the name of the river or creek, the locality at or near which the measurements were made, and, in the third column, the area of the drainage basin above this point. In the fourth column is given the time during which the measurements or computations of discharge were continued. In cases where these have been carried on for a whole year the date of the last day is given, as, for example, "year ended August 31, 1890", signifies that the daily discharge was computed from September 1, 1889, to August 31, 1890. In cases where only a single measurement was made the date of that measurement alone is given. In the fifth, sixth, and seventh columns are given, respectively, the maximum, minimum, and mean discharges in cubic feet per second, or second-feet, a second-foot of water being the quantity discharged by a stream one foot wide and one foot deep flowing at an average velocity of one foot per second. In many instances the maximum and minimum discharges have not been ascertained, and in cases where only a single measurement has been made this is given under the column of mean discharge. This amount can be expressed in still another unit in popular use in the arid region, namely, the miner's inch. This unfortunately is an indefinite quantity, varying with the method of measurement and the character of the aperture through which the water flows. It may be assumed that in round numbers 50 California miner's inches make 1 second-foot, and in Colorado and adjoining states 40 miner's inches or even less are equivalent to the same fixed quantity. To obtain, therefore, the discharge in miner's inches the amounts given in second-feet can be multiplied by 40 or 50. In the footnotes reference is made to the report or volume from which these figures were obtained.

TABLE 16.—WATER SUPPLY OF ARID REGION, AS SHOWN BY RESULTS OF STREAM MEASUREMENTS.

ARIZONA.

| RIVERS AND CREEKS. | Locality. | Drainage area in square miles. | Time. | DISCHARGE IN SECOND-FEET. | | |
|---|---|---|---|---|---|---|
| | | | | Maximum. | Minimum. | Mean. |
| San Pedro (a) | Dudleyville | 2,819 | April 9 to August 31, 1890 | 507 | 1 | 70 |
| Gila (a) | Buttes | 13,750 | Year ended August 31, 1890 | 6,330 | 11 | 503 |
| Verde (a) | Fort McDowell | 6,000 | August 14 to September 30, 1890 | 480 | 140 | 200 |
| Salt (b) | Arizona dam | 12,260 | Year ended December 31, 1889 | 33,794 | 319 | 2,576 |
| Salt (b) | Arizona dam | 12,260 | Year ended December 31, 1890 | 143,288 | 397 | 3,771 |
| Salt (b) | Arizona dam | 12,260 | Year ended February 28, 1891 | 300,000 | 397 | 6,066 |
| Salt (a) | In cañon | 5,880 | May 28 to August 31, 1890 | 2,200 | 185 | 599 |
| Colorado (c) | Stone Ferry, Nevada | | August 12, 1875 | | | 18,410 |
| Colorado (c) | Camp Mohave | | September 2, 1875 | | | 11,611 |
| Colorado (c) | Yuma | | March 20, 1876 | | | 7,659 |

CALIFORNIA.

| | | | | | | |
|---|---|---|---|---|---|---|
| Sacramento (d) | Collinsville | 26,187 | 6 years, November 1, 1878, to October 31, 1884 | 160,000 | 5,050 | 37,632 |
| Cosumnes (d) | Live Oak | 580 | 6 years, November 1, 1878, to October 31, 1884 | | | 1,234 |
| Dry creek (d) | Foothills | 283 | 6 years, November 1, 1878, to October 31, 1884 | | | 237 |
| Mokelumne (d) | Lone Star mill | 657 | 6 years, November 1, 1878, to October 31, 1884 | 9,642 | 134 | 1,321 |
| Calaveras (d) | Bellota | 491 | 6 years, November 1, 1878, to October 31, 1884 | | | 320 |
| Stanislaus (d) | Oakdale | 1,051 | 6 years, November 1, 1878, to October 31, 1884 | 10,980 | 330 | 1,958 |
| Tuolumne (d) | Modesto | 1,501 | 6 years, November 1, 1878, to October 31, 1884 | 22,900 | 130 | 2,685 |
| Merced (d) | Merced Falls | 1,076 | 6 years, November 1, 1878, to October 31, 1884 | | | 1,631 |
| Bear creek (d) | Base of foothills | 166 | 6 years, November 1, 1878, to October 31, 1884 | 2,080 | | 65 |
| Mariposa creek (d) | Base of foothills | 122 | 6 years, November 1, 1878, to October 31, 1884 | | | 46 |
| Chowchilla creek (d) | Base of foothills | 268 | 6 years, November 1, 1878, to October 31, 1884 | 10,770 | | 152 |
| Fresno (d) | Base of foothills | 272 | 6 years, November 1, 1878, to October 31, 1884 | 202 | | 167 |
| San Joaquin (d) | Hamptonville | 1,637 | 6 years, November 1, 1878, to October 31, 1884 | 59,800 | 260 | 3,074 |
| Kings (d) | Slate Point | 1,742 | 6 years, November 1, 1878, to October 31, 1884 | | | 2,584 |
| Kaweah (d) | Wachumna | 619 | 6 years, November 1, 1878, to October 31, 1884 | | | 723 |
| Tule (d) | Porterville | 437 | 6 years, November 1, 1878, to October 31, 1884 | | | 451 |
| Deer creek (d) | Base of foothills | 110 | 6 years, November 1, 1878, to October 31, 1884 | | | 49 |
| White creek (d) | Base of foothills | 90 | 6 years, November 1, 1878, to October 31, 1884 | | | 40 |
| Poso creek (d) | Base of foothills | 289 | 6 years, November 1, 1878, to October 31, 1884 | | | 145 |
| Kern (d) | Rio Bravo ranch | 2,345 | 6 years, November 1, 1878, to October 31, 1884 | 4,070 | 145 | 1,110 |
| Caliente (d) | Base of foothills | 423 | 6 years, November 1, 1878, to October 31, 1884 | | | 191 |
| Prosser creek (a) | Near Boca | 56 | April 1 to September 30, 1889 | | | 82 |
| Prosser creek (a) | Near Boca | 56 | April 1 to August 31, 1890 | 1,230 | 75 | 295 |
| Little Truckee (a) | Boca | 179 | April 2 to October 31, 1890 | 2,867 | 70 | 805 |
| Truckee (a) | Boca | 902 | March 24 to October 31, 1890 | 7,172 | 490 | 2,079 |
| Truckee (a) | Tahoe City | 522 | July 4 to August 18, 1889 | | | 79 |
| Squaw (a) | Mouth | 8 | June, 1889 | | | 53 |
| Toll Gate (a) | | | June 3, 1889 | | | 74 |
| Donner (a) | Below Donner lake | 16 | July 3 to August 17, 1889 | | | 3 |
| Cold (a) | Near Donner lake | 14 | June 28 to August 17, 1889 | | | 4 |

*a* Eleventh annual report of the United States Geological Survey, part 2, 1889–1890; Washington, 1891; pages 93–110.

*b* Twelfth annual report of the United States Geological Survey, part 2, 1890–1891; Washington, 1892; page 313.

*c* Twelfth annual report of the United States Geological Survey, part 2, pages 291, 292.

*d* Physical data and statistics of California, collected and compiled by the state engineering department of California, Wm. Ham. Hall, state engineer; Sacramento, 1886; pages 412–477.

TABLE 16.—WATER SUPPLY OF ARID REGION, AS SHOWN BY RESULTS OF STREAM MEASUREMENTS—Continued.

COLORADO.

| RIVERS AND CREEKS. | Locality. | Drainage area in square miles. | Time. | DISCHARGE IN SECOND-FEET. | | |
|---|---|---|---|---|---|---|
| | | | | Maximum. | Minimum. | Mean. |
| Cache la Poudre (a) | Above Fort Collins | 1,060 | March 15 to October 16, 1884 | 5,611 | 48 | 1,385 |
| Cache la Poudre (a) | Above Fort Collins | 1,060 | April 4 to October 10, 1885 | 3,857 | 202 | 1,109 |
| Cache la Poudre (a) | Above Fort Collins | 1,060 | April 27 to October 31, 1886 | 2,660 | 115 | 708 |
| Cache la Poudre (a) | Above Fort Collins | 1,060 | May 18 to September 30, 1887 | 2,380 | 110 | 888 |
| Cache la Poudre (a) | Above Fort Collins | 1,060 | April 1 to September 30, 1888 | 1,490 | 70 | 420 |
| Cache la Poudre (a) | Above Fort Collins | 1,060 | Year ended December 31, 1889 | 1,960 | 33 | 283 |
| Cache la Poudre (a) | Above Fort Collins | 1,060 | Year ended December 31, 1890 | 1,804 | 37 | 335 |
| Cache la Poudre (a) | Above Fort Collins | 1,060 | Year ended May 31, 1891 | 2,080 | 41 | 440 |
| Arkansas (a) | Cañon City | 3,060 | Year ended December 31, 1888 | 2,760 | 430 | 860 |
| Arkansas (a) | Cañon City | 3,060 | Year ended December 31, 1889 | 2,620 | 190 | 433 |
| Arkansas (a) | Cañon City | 3,060 | Year ended December 31, 1890 | 3,270 | 180 | 874 |
| Arkansas (a) | Cañon City | 3,060 | Year ended December 31, 1891 | 4,230 | 325 | 1,012 |
| Arkansas (b) | Rock cañon | 4,560 | May to August, 1889 | 4,375 | 405 | 1,210 |
| Arkansas (b) | Pueblo | 4,600 | Year ended December 31, 1886 | 7,659 | 400 | 1,441 |
| Arkansas (b) | Pueblo | 4,600 | Year ended December 31, 1887 | 6,510 | 400 | 1,323 |
| Arkansas (b) | La Junta | 12,200 | May 20 to August 31, 1889 | 2,620 | 55 | 931 |
| Purgatoire (b) | Las Animas | 3,040 | May 22 to September 30, 1889 | 1,770 | 6 | 92 |
| Rio Grande (a) | Del Norte | 1,400 | Year ended December 31, 1890 | 5,930 | 307 | 1,242 |
| Rio Grande (a) | Del Norte | 1,400 | Year ended December 31, 1891 | 5,650 | 290 | 1,403 |
| East fork, Arkansas (b) | Near Leadville | 44 | April 25 to October 31, 1890 | 458 | 5 | 95 |
| Tennessee fork (b) | Near Leadville | 44 | May 11 to October 31, 1890 | 315 | 29 | 91 |
| Lake fork (b) | Near Leadville | 21 | April 23 to October 31, 1890 | 528 | 19 | 116 |
| Twin Lake creek (b) | Below Twin lakes | 102 | April 19 to October 31, 1890 | 632 | 19 | 212 |
| Clear creek (b) | Near Granite | 72 | April 20 to October 31, 1890 | 420 | 12 | 133 |
| Middle Cottonwood (b) | Near Buena Vista | 37 | April 16 to August 31, 1890 | 155 | 12 | 65 |
| South Cottonwood (b) | Near Buena Vista | 28 | April 16 to August 31, 1890 | 145 | 5 | 71 |
| St. Vrain (c) | Below Lyons station | 209 | April 10 to September 11, 1887 | 250 | 75 | 142 |
| St. Vrain (c) | Below Lyons station | 209 | April 3 to October 8, 1888 | 480 | 30 | 147 |
| St. Vrain (d) | Below Lyons station | 209 | May 20 to October 31, 1889 | 548 | 26 | 209 |
| St. Vrain (d) | Below Lyons station | 209 | May 15 to November 15, 1890 | 590 | 18 | 203 |
| South Platte (c) | Cañon | 2,600 | July 11 to October 15, 1887 | 690 | 220 | 455 |
| South Platte (c) | Cañon | 2,600 | March 25 to October 20, 1888 | 800 | 100 | 328 |
| South Platte (d) | Cañon | 2,600 | April 22 to October 31, 1889 | 782 | 100 | 279 |
| South Platte (d) | Cañon | 2,600 | May 1 to October 31, 1890 | 875 | 112 | 374 |
| South Platte (d) | Denver | 3,870 | May 1 to October 31, 1889 | 1,315 | 54 | 181 |
| South Platte (d) | Denver | 3,870 | June 14 to October 31, 1890 | 1,202 | 45 | 247 |
| Bear (c) | 2.5 miles above Morrison | 141 | August 17 to October 12, 1887 | 100 | 80 | 90 |
| Bear (c) | 2.5 miles above Morrison | 141 | April 1 to October 7, 1888 | 160 | 15 | 80 |
| Bear (d) | 2.5 miles above Morrison | 141 | May 3 to August 10, 1889 | 195 | 18 | 73 |
| Bear (d) | 2.5 miles above Morrison | 141 | May 20 to November 15, 1890 | 68 | 15 | 30 |
| North Boulder (c) | 4 miles above Boulder | 102 | August 20 to November 5, 1887 | 150 | 20 | 87 |
| North Boulder (c) | 4 miles above Boulder | 102 | April 1 to October 13, 1888 | 320 | 5 | 153 |
| North Boulder (d) | 4 miles above Boulder | 102 | May 7 to October 31, 1889 | 785 | 16 | 294 |
| North Boulder (d) | 4 miles above Boulder | 102 | May 13 to November 9, 1890 | 453 | 24 | 169 |
| South Boulder (c) | Kneales sawmill | | April 6 to October 11, 1888 | 250 | 25 | 112 |
| South Boulder (d) | Kneales sawmill | | May 26 to November 2, 1889 | 560 | 15 | 171 |
| South Boulder (d) | Kneales sawmill | | May 9 to October 29, 1890 | 535 | 28 | 157 |
| Big Thompson (c) | 10 miles west of Loveland | 305 | April 25 to September 20, 1887 | 330 | 95 | 169 |
| Big Thompson (c) | 10 miles west of Loveland | 305 | April 3 to October 8, 1888 | 880 | 15 | 216 |
| Big Thompson (d) | 10 miles west of Loveland | 305 | May 15 to October 31, 1889 | 546 | 28 | 187 |
| Big Thompson (d) | 10 miles west of Loveland | 305 | May 8 to November 15, 1890 | 1,603 | 51 | 302 |
| Clear creek (c) | 7 miles above Golden | 338 | August 3 to October 16, 1887 | 500 | 160 | 332 |
| Clear creek (c) | 7 miles above Golden | 338 | March 24 to September 29, 1888 | 8,700 | 60 | 283 |
| Uncompahgre (d) | 8 miles above Montrose | 554 | July 10 to October 18, 1890 | 441 | 114 | 206 |
| South Platte (e) | 6 miles above Fairplay | | July 3, 1876 | | | 388 |
| South Platte (e) | Above mouth Little Platte | | June 29, 1876 | | | 367 |
| South Platte (e) | Colorado Springs road | | June 23, 1876 | | | 1,015 |
| South Platte (e) | Foot of cañon | | September 8, 1876 | | | 1,400 |
| South Platte (e) | Denver | | December, 1876 | | | 492 |
| South Platte (e) | 2 miles above Denver | | Low water, 1876 | | | 204 |
| Clear creek (e) | Golden | | September 3, 1876 | | | 374 |
| Clear creek (e) | Golden | | August 27, 1876 | | | 536 |

*a* Twelfth annual report of the United States Geological Survey, part 2, pages 327, 346–358.

*b* Eleventh annual report of the United States Geological Survey, part 2, 1889–1890; Washington, 1891; pages 93–110.

*c* Fourth biennial report of the state engineer of Colorado, part 2; Denver, 1889; plates 17–23.

*d* Fifth biennial report of the state engineer of Colorado; Denver, 1890; pages 24–41.

*e* Tenth annual report of the United States Geological and Geographical Survey; F. V. Hayden, Washington, 1878. Report on the arable and pasture lands of Colorado, Henry Gannett, pages 324, 325, 327, 334, and 338.

TABLE 16.—WATER SUPPLY OF ARID REGION, AS SHOWN BY RESULTS OF STREAM MEASUREMENTS—Continued.

COLORADO—Continued.

| RIVERS AND CREEKS. | Locality. | Drainage area in square miles. | Time. | DISCHARGE IN SECOND-FEET. | | |
|---|---|---|---|---|---|---|
| | | | | Maximum. | Minimum. | Mean. |
| Clear creek (a) | Golden | | June 19, 1876 | | | 1,765 |
| Arkansas (a) | Cañon City | | End of August, 1876 | | | 2,050 |
| Arkansas (a) | Cañon City | | November, 1876 | | | 670 |
| Arkansas (a) | Pueblo | | November, 1876 | | | 608 |
| Arkansas (a) | Pueblo | | June, 1876 | | | 4,614 |
| Gunnison (a) | Head of Uncompahgre valley | | September, 1876 | | | 356 |
| Yampa (a) | Ford | | November, 1876 | | | 364 |
| **IDAHO.** | | | | | | |
| Bear (b) | Battle Creek | 4,500 | Year ended December 31, 1890 | 5,980 | 270 | 1,751 |
| Bear (b) | Battle Creek | 4,500 | Year ended December 31, 1891 | 3,030 | 690 | 1,224 |
| Henry (b) | In cañon | 931 | Year ended December 31, 1890 | 7,710 | 1,120 | 1,719 |
| Henry (b) | In cañon | 931 | Year ended June 30, 1891 | 3,180 | 1,280 | 1,458 |
| Falls (b) | In cañon | 594 | Year ended March 31, 1891 | 4,440 | 450 | 1,194 |
| Falls (b) | In cañon | 594 | Year ended December 31, 1891 | 2,790 | 450 | 773 |
| Teton (b) | Chase | 967 | Year ended March 31, 1891 | 4,445 | 400 | 1,021 |
| Teton (b) | Chase | 967 | Year ended December 31, 1891 | 2,360 | 400 | 696 |
| Snake (b) | Idaho Falls | 10,100 | Year ended June 30, 1890 | 50,450 | 2,000 | 8,335 |
| Snake (b) | Idaho Falls | 10,100 | Year ended December 31, 1890 | 50,450 | 2,000 | 10,635 |
| Weiser (b) | In cañon | 1,670 | Year ended February 28, 1891 | 11,220 | 80 | 1,652 |
| Weiser (b) | In cañon | 1,670 | Year ended June 30, 1891 | 9,300 | 80 | 771 |
| **MONTANA.** | | | | | | |
| West Gallatin (b) | 20 miles above Bozeman | 850 | Year ended December 31, 1890 | 3,800 | 320 | 871 |
| West Gallatin (b) | 20 miles above Bozeman | 850 | Year ended December 31, 1891 | 2,975 | 370 | 880 |
| West Gallatin (c) | Near mouth | 1,770 | July, 1872 | | | 2,090 |
| Madison (b) | Red Bluff | 2,085 | Year ended December 31, 1890 | 6,420 | 1,285 | 2,068 |
| Madison (b) | Red Bluff | 2,085 | Year ended December 31, 1891 | 4,620 | 1,070 | 1,872 |
| Madison (c) | Near mouth | 2,285 | July, 1872 | | | 2,670 |
| Madison (d) | Blacks | 2,085 | August 17, 1889 | | | 1,104 |
| Madison (d) | Three Forks | 2,285 | October 14, 1889 | | | 1,191 |
| Red Rock (d) | Allerdice | 860 | September 6, 1889 | | | 10 |
| Red Rock (d) | Red Rock | 1,330 | Year ended December 31, 1890 | 675 | 40 | 148 |
| Big Hole (d) | Melrose | 2,335 | September 8, 1889 | | | 60 |
| Blacktail Deer (d) | Poindexter | 300 | September 4, 1889 | | | 10 |
| Beaverhead (d) | Dillon | 4,000 | September 9, 1889 | | | 75 |
| Ruby (d) | Laurin | 710 | September 4, 1889 | | | 90 |
| Jefferson (c) | Mouth | 9,400 | July, 1872 | | | 3,778 |
| Jefferson (d) | Willow creek | 2,280 | August 19, 1889 | | | 202 |
| Jefferson (d) | Three Forks | 9,400 | October 15, 1889 | | | 333 |
| Dearborn (c) | Mouth | 484 | 1882 | | | 622 |
| Dearborn (d) | Dearborn | 350 | August 9, 1889 | | | 47 |
| Dearborn (d) | Dearborn | 350 | April 15, 1890 | | | 37 |
| Deep creek (c) | Mouth | 3,205 | 1882 | | | 1,800 |
| Sun (b) | Augusta | 1,175 | Year ended December 31, 1890 | 4,085 | 160 | 715 |
| Teton (d) | Chotean | 900 | August 7, 1889 | | | 26 |
| North Musselshell (d) | Martindale | 250 | August 17, 1889 | | | 15 |
| South Musselshell (d) | Martindale | 290 | August 17, 1889 | | | 10 |
| Big Elk (d) | Big Timber road | 100 | August 17, 1889 | | | 10 |
| Lebo (d) | Big Timber road | 10 | August 17, 1889 | | | 8 |
| American fork (d) | Big Timber road | 55 | August 17, 1889 | | | 3 |
| Missouri (c) | Three Forks | 13,415 | July, 1872 | | | 8,538 |
| Missouri (c) | Three Forks | 13,415 | July 28, 1890 | | | 2,863 |
| Missouri (c) | Below Gallatin | 13,415 | August 6, 1890 | | | 2,460 |
| Missouri (c) | Cañon ferry | 15,036 | September 18, 1890 | | | 2,682 |
| Missouri (c) | 71 miles below Three Forks | 15,080 | July 31, 1872 | | | 10,000 |
| Missouri (c) | Stubbs, 73 miles below Three Forks. | 15,121 | 1882 | | | 3,770 |
| Missouri (b) | Craig | 17,615 | Year ended December 31, 1890 | 12,500 | 1,742 | 4,307 |
| Missouri (b) | Craig | 17,615 | Year ended December 31, 1891 | 16,355 | 1,742 | 5,503 |

a Tenth annual report of the United States Geological and Geographical Survey; F. V. Hayden, Washington, 1878. Report on the arable and pasture lands of Colorado, Henry Gannett, pages 324, 325, 327, 334, and 338.

b Twelfth annual report of the United States Geological Survey, part 2, pages 327, 346–358.

c Twelfth annual report of the United States Geological Survey, part 2, pages 236, 237, and 240.

d Eleventh annual report of the United States Geological Survey, part 2, 1889–1890; Washington, 1891; pages 93–110.

TABLE 16.—WATER SUPPLY OF ARID REGION, AS SHOWN BY RESULTS OF STREAM MEASUREMENTS—Continued.

MONTANA—Continued.

| RIVERS AND CREEKS. | Locality. | Drainage area in square miles. | Time. | DISCHARGE IN SECOND-FEET. | | |
|---|---|---|---|---|---|---|
| | | | | Maximum. | Minimum. | Mean. |
| Missouri (a) | Below Sun river | 23,540 | 1882 | | | 19,425 |
| Missouri (a) | Below Fort Benton | 25,007 | August 12, 1872 | | | 11,132 |
| Missouri (a) | Dauphin rapids | 39,247 | 1878 | | | 11,062 |
| Missouri (a) | Ryan island | 39,965 | October 20, 1882 | | | 7,305 |
| Yellowstone (b) | Horr | 2,700 | Year ended December 31, 1890 | 11,915 | 510 | 3,181 |
| Yellowstone (b) | Horr | 2,700 | Year ended December 31, 1891 | 8,975 | 285 | 2,421 |
| Yellowstone (c) | Spriogdale | 4,800 | Fall, 1889 | | | 1,874 |
| Shields creek (c) | Flathead creek | 225 | August 3, 1889 | | | 25 |
| Pine (c) | Shields creek | 42 | August 3, 1889 | | | 10 |
| Bracket (c) | Shields creek | 66 | August 3, 1889 | | | 10 |
| Rock (c) | Shields creek | 50 | August 3, 1889 | | | 15 |
| Shields river (c) | Below Rock creek | 670 | August 3, 1889 | | | 65 |
| Sweet creek (c) | Big Timber road | 100 | August 17, 1889 | | | 35 |
| Big Timber (c) | Big Timber road | 63 | August 17, 1889 | | | 40 |
| Tongue (c) | Miles City | 3,875 | October 6, 1889 | | | 200 |
| **NEVADA.** | | | | | | |
| Truckee (c) | Essex | 991 | May 1 to September 30, 1889 | | | 727 |
| Truckee (c) | Laughtons | 1,054 | May 13 to September 30, 1890 | 6,310 | 320 | 2,433 |
| Truckee (b) | Vista | 1,519 | Year ended March 31, 1891 | 7,510 | 400 | 1,895 |
| Truckee (b) | Vista | 1,519 | Year ended December 31, 1891 | 3,285 | 370 | 980 |
| Martis (c) | Mouth | 45 | June, 1889 | | | 13 |
| Juniper (c) | Clinton | 10 | May 30, 1889 | | | 22 |
| Joe Grey (c) | Cuba | 17 | June, 1889 | | | 52 |
| Bronco (c) | Bronco | 19 | May 31, 1889 | | | 42 |
| Dog (c) | Verde | 22 | May 22, 1889 | | | 7 |
| East Carson (b) | Rodenbah | 414 | Year ended March 31, 1891 | 4,260 | 375 | 970 |
| East Carson (b) | Rodenbah | 414 | Year ended December 31, 1891 | 1,884 | 375 | 619 |
| West Carson (b) | Woodfords, California | 70 | Year ended March 31, 1891 | 1,284 | 42 | 206 |
| West Carson (b) | Woodfords, California | 70 | Year ended December 31, 1891 | 740 | 34 | 128 |
| Carson (c) | Empire | 894 | April 16 to September 30, 1890 | 6,278 | 131 | 1,874 |
| **NEW MEXICO.** | | | | | | |
| Rio Grande (b) | Embudo | 7,000 | Year ended December 31, 1889 | 5,660 | 181 | 1,032 |
| Rio Grande (b) | Embudo | 7,000 | Year ended December 31, 1890 | 6,071 | 260 | 1,467 |
| Rio Grande (b) | Embudo | 7,000 | Year ended December 31, 1891 | 8,550 | 225 | 1,855 |
| Rio Grande (b) | El Paso | 30,000 | Year ended April 30, 1890 | 4,705 | | 755 |
| Rio Grande (b) | El Paso | 30,000 | Year ended December 31, 1890 | 7,200 | 40 | 1,327 |
| Rio Grande (b) | El Paso | 30,000 | Year ended December 31, 1891 | 16,620 | | 2,653 |
| Rio Chama (c) | Abiquiu | 2,300 | March 9, 1889 | | | 945 |
| Rio Grande (c) | San Ildefonso | 11,250 | March 9, 1889 | | | 698 |
| Rio Grande (c) | San Marcial | | August 8, 1889 | | | 19 |
| Jemez (c) | Canyones | 900 | Spring, 1889 | | | 84 |
| Jemez (c) | Canyones | 900 | Summer, 1889 | | | 25 |
| **OREGON.** | | | | | | |
| Owyhee (b) | Rigsbys | 9,875 | Year ended March 31, 1891 | 11,230 | 170 | 1,656 |
| Owyhee (b) | Rigsbys | 9,875 | Year ended December 31, 1891 | 10,000 | 200 | 1,332 |
| Malheur (b) | Vale | 9,900 | Year ended February 28, 1891 | 4,445 | 15 | 698 |
| Malheur (b) | Vale | 9,900 | Year ended September 30, 1891 | 2,820 | 15 | 187 |

*a* Twelfth annual report of the United States Geological Survey, part 2, pages 236, 237, and 240.
*b* Twelfth annual report of the United States Geological Survey, part 2, pages 327, 346–358.
*c* Eleventh annual report of the United States Geological Survey, part 2, 1889-1890; Washington, 1891; pages 93–110.

TABLE 16.—WATER SUPPLY OF ARID REGION, AS SHOWN BY RESULTS OF STREAM MEASUREMENTS—Continued.

UTAH.

| RIVERS AND CREEKS. | Locality. | Drainage area in square miles. | Time. | DISCHARGE IN SECOND-FEET. | | |
|---|---|---|---|---|---|---|
| | | | | Maximum. | Minimum. | Mean. |
| Bear (a) | Collinston | 6,000 | Year ended June 30, 1890 | 8,220 | 340 | 3,255 |
| Bear (a) | Collinston | 6,000 | Year ended December 31, 1890 | 8,220 | 1,000 | 2,945 |
| Bear (a) | Collinston | 6,000 | Year ended December 31, 1891 | 5,000 | 825 | 1,847 |
| Ogden (a) | Powder mills | 360 | Year ended July 31, 1890 | 2,178 | 40 | 616 |
| Ogden (a) | Powder mills | 360 | Year ended December 31, 1890 | 2,178 | 215 | 663 |
| Weber (a) | Devil Gate | 1,600 | Year ended December 31, 1890 | 5,465 | 200 | 1,070 |
| Weber (a) | Devil Gate | 1,600 | Year ended December 31, 1891 | 4,655 | 240 | 880 |
| American fork (b) | Cañon | 66 | Year ended July 31, 1890 | 885 | 6 | 146 |
| Provo (a) | Provo | 640 | Year ended December 31, 1890 | 2,260 | 200 | 572 |
| Provo (a) | Provo | 640 | Year ended December 31, 1891 | 1,704 | 200 | 503 |
| Spanish fork (a) | Cañon | 670 | Year ended December 31, 1890 | 1,040 | 50 | 172 |
| Sevier (a) | Leamington | 5,595 | Year ended December 31, 1890 | 2,329 | 150 | 625 |
| Sevier (a) | Leamington | 5,595 | Year ended December 31, 1891 | 1,386 | 140 | 535 |
| Bear (a) | Above Smith Fork | | August 24, 1877 | | | 112 |
| Bear (a) | Soda Springs | | August 17, 1877 | | | 1,000 |

WYOMING.

| | | | | | | |
|---|---|---|---|---|---|---|
| Yellowstone (b) | Yellowstone lake | 1,100 | August 25, 1875 | | | 1,200 |
| Yellowstone (b) | Yellowstone lake | 1,100 | September, 1886 | | | 1,273 |
| Yellowstone (b) | Yellowstone lake | 1,100 | October 9, 1889 | | | 583 |
| North Platte (c) | Below Fort Laramie | 21,200 | Year ended December 31, 1887 | 10,140 | 3,000 | 4,007 |
| North Platte (c) | Below Fort Laramie | 21,200 | Year ended December 31, 1888 | 6,490 | 3,000 | 3,713 |
| North Platte (c) | Below Fort Laramie | 21,200 | Year ended December 31, 1889 | 10,260 | 2,370 | 3,769 |
| North Platte (c) | Below Fort Laramie | 21,200 | Year ended December 31, 1890 | 10,240 | 2,600 | 4,116 |

a Twelfth annual report of the United States Geological Survey, part 2, pages 327, 346-358.
b Eleventh annual report of the United States Geological Survey, part 2, 1889-1890; Washington, 1891; pages 93-110.
c Twelfth annual report of the United States Geological Survey, part 2, pages 236, 237, and 240.

In the foregoing table are given some of the main facts concerning quantities of water either at one particular time or during periods of months or years. As is well known, the amount of water in any stream varies greatly from day to day and from year to year, and results obtained on any one day or even during a year to be of value must be intelligently used and the fact kept in mind that there is no unvarying regularity or certainty of behavior of the stream. On the other hand, these data obtained by direct measurements, though in themselves indecisive, furnish the only reliable basis upon which to compute the water supply available or the amount which can be depended upon with a reasonable degree of confidence. Any discussion of the agricultural possibilities of the arid region to be of value must make use of such data, and in like manner any irrigation enterprise to be entered upon with confidence must be preceded by a thorough examination of the amount and character of the flow of the streams of the particular neighborhood.

The fluctuations of river flow can be considered under two general classes, one the periodic rise and fall, and the other the change from year to year. The former is somewhat regular in character and in time of appearance, but the latter is exceedingly variable and is not reducible to any rule or order. There are, however, certain general limits or extremes which any one stream at a particular locality rarely passes, although streams differ from each other greatly in this regard. There is also for each stream an average spring and summer flow, which when once ascertained makes possible a reasonably correct estimate of its value for irrigation. The chances of unusual flood or drought, however, must not at any time be forgotten.

The stream measurements given above must be used with due consideration of these general principles. For example, a measurement made on a single day applies strictly to that day, and that day only, but by taking into consideration the season of the year and also the general character of the year, whether one of drought or floods, a useful conclusion can be drawn. The measurements continued through a year have of course far greater value, but in the same way the character of the year should be borne in mind.

The periodic or annual fluctuations of water supply have a very immediate bearing upon the agricultural capabilities of an arid country, since at the time of the yearly flood the amount of water increases two, three, four, or even up to ten times that which flows during the remainder of the year. If the flood season occurs, as it unfortunately does in many localities, early in the spring, before irrigation is necessary, the greater part of this valuable water is lost. If, on the other hand, the floods occur later and coincide with the height of the irrigating season, the advantage to the country can hardly be overestimated.

The nonperiodic fluctuation or variation from year to year is a matter of the greatest concern in irrigation development. It is comparatively easy to adapt the methods and systems of irrigation to the regularly occurring floods and to economize these by storage reservoirs, but this fluctuation from year to year, perhaps a gradual increase of water supply through several years and then a decline to one-half, one-third, or a still smaller proportion of the usual supply, bears heavily upon the resources of the irrigator and destroys the confidence of the public at large.

### DUTY OF WATER.

The duty of water is the term used to express the relation between the quantity of water used in irrigation and the area upon which it is employed. If a given stream flowing at the rate of 10 second-feet irrigates throughout the season 1,000 acres, it is said that the duty of water is 100 acres to the second-foot. The duty, as might be inferred, differs very widely with the character of the water supply, the methods of employing it, the character of the soil and crops, and perhaps more than all with the skill and experience of the irrigator. It is necessary, however, to assume certain averages in order to ascertain the value of flowing water.

The average duty of water most widely accepted is that originally taken by Powell as 100 acres to the second-foot. In practice some irrigators undoubtedly reach a higher value and others a lower one. Throughout the arid region there is a popular expression of "1 inch to the acre"; that is to say, water flowing in a stream of moderate size will irrigate at the rate of 1 miner's inch to the acre. This would give an extremely low duty of only 40 or 50 acres to the second-foot, but it is probable that in many localities where there is an ample water supply it is used as freely as this. The saying is so common that the majority of the irrigators who have formed any opinion on the subject have given this as the common practice. Nevertheless there can be little doubt that a higher duty is generally obtained.

Upon the new lands of Utah, Idaho, and Montana it is probable that the duty of water averages about 70 acres to the second-foot, and that it can be readily brought up to 100 acres. In California, in localities where water is scarce and great care is taken in using it, the duty has been found to be 200 acres or more, in exceptional cases rising to 500 acres or over, this high water duty being obtained usually in the case of orchards, in which the water is conducted by pipes to each tree. The state engineer of Colorado in the fifth biennial report estimates the duty of water of certain streams at from 168 to 424 acres per second-foot, using in this connection the acreage estimated by the water commissioners. By substituting the acreage from which crops were obtained as shown by this census, the duty has been found to be from 90 to 200 acres to the second-foot. This high duty of water is unquestionably due to the fact that some of the water returns by seepage to the stream and is used a second time. As a conservative estimate, as well as a convenient one, 100 acres to the second-foot may be considered as the average duty which has been obtained under favorable conditions and by the employment of ordinary skill on the part of the irrigator.

### VALUE OF FLOWING WATER.

By taking a definite quantity to represent the duty of water, viz, 100 acres to the second-foot, and by ascertaining the average value of this water to the land, it is possible to obtain some conception of the value of the water resources of the country. Taking from Table 11 the average value of the water right per acre as $26.00 and the average first cost per acre as $8.15, the difference, $17.85, previously regarded in the light of profit to the irrigator, can be considered as the value of the flowing water to each acre. If, then, one second-foot irrigates 100 acres, its value under these assumptions is $1,785. A small river or creek carrying throughout the irrigating season 100 second-feet should be worth at least $178,500. By using this ratio it is a simple matter of multiplication to estimate from Table 16 the value of the rivers there mentioned. As these form but a small part of the water resources of the country, it is impossible from this alone to sum up the total value to agriculture of the rivers of the arid region. An approximation of the total water supply can, however, be made in another manner and its value arrived at in this way.

From an examination of all the material at hand it appears that almost without exception the water supply of use for irrigation comes from rugged mountains, that is, from a country whose topography is highly diversified. There are minor exceptions to this, as, for example, in Texas, where the supply comes largely from springs deriving water from the rainfall upon prairie regions. Within the limits of the arid region it has been estimated that there are approximately 360,000 square miles of rugged, mountainous country from which perennial streams issue, this being about 30 per cent of the area usually termed "arid". The rest of the country consists of valleys, plateaus, and undulating areas from whose surface comparatively few perennial streams flow.

By inspection of the data contained in Table 16 it has been found that the mountainous areas above mentioned contribute to some stream on an average, in round numbers, one second-foot to every square mile drained. The whole area of mountainous country should then furnish water to all of the rivers at the mean annual rate of about 360,000 second-feet. As a matter of fact not all of this water can be used, since some of it quickly escapes through deep gorges far below the level of the agricultural lands. Aside from this consideration and taking the simplest

form of statement, the total area irrigable at a water duty of 100 acres to the second-foot would be 36,000,000 acres, and the total value of the water at the rate given above would be $642,600,000, but with a higher water duty the area and value would be correspondingly increased.

## IRRIGATION BY ARTESIAN WELLS.

The total number of artesian wells used for irrigation during the census year has been ascertained to be 3,930, furnishing water for 51,896 acres, or 1.43 per cent of the total area irrigated. The total number of artesian wells upon farms in June, 1890, in the 14 states and territories forming the western part of the United States was 8,097. The average depth was 210.41 feet, the average cost $245.58, and the average discharge 54.43 gallons per minute, irrigating 13.21 acres per well. Out of the total number of 8,097 artesian wells complete statistics were obtained concerning 2,971, or 36.69 per cent. From this latter number of wells, fairly distributed through each state and county, averages have been drawn, which when applied to the entire number give the results shown in Table 17.

TABLE 17.—ARTESIAN WELLS ON FARMS IN JUNE, 1890.

| STATES AND TERRITORIES. | Total number. | Average depth in feet. | Average cost per well. | Average discharge in gallons per minute. | WELLS USED IN IRRIGATION. | | Acres irrigated per well. | Total acreage irrigated. |
|---|---|---|---|---|---|---|---|---|
| | | | | | Per cent. | Computed number. | | |
| Total | 8,097 | 210.41 | $245.58 | 54.43 | 48.54 | 3,930 | 13.21 | 51,896 |
| California | 3,210 | 248.00 | 425.00 | 164.00 | 64.17 | 2,060 | 18.63 | 38,378 |
| Colorado | 596 | 251.00 | 221.00 | 39.00 | 57.85 | 345 | 18.01 | 6,213 |
| Idaho | 28 | 83.00 | 53.00 | 11.00 | 50.00 | 14 | 13.21 | 185 |
| Kansas | 59 | 202.00 | 175.00 | 44.00 | 41.37 | 24 | 13.71 | 329 |
| Montana | 14 | 366.00 | 473.00 | 28.00 | 42.85 | 6 | 3.00 | 18 |
| Nebraska | 91 | 247.00 | 173.00 | 13.00 | 7.40 | 7 | 1.00 | 7 |
| Nevada | 33 | 215.00 | 607.00 | 6.00 | 60.00 | 20 | 1.00 | 20 |
| North Dakota | 461 | 196.00 | 265.00 | 21.00 | 2.17 | 10 | 2.00 | 20 |
| Oregon | 6 | 70.00 | 250.00 | 15.00 | 50.00 | 3 | 4.00 | 12 |
| South Dakota | 527 | 216.00 | 158.00 | 51.00 | 13.46 | 71 | 6.68 | 474 |
| Texas | 534 | 292.00 | 359.00 | 19.00 | 27.32 | 146 | 3.00 | 438 |
| Utah | 2,524 | 146.00 | 78.00 | 26.00 | 48.49 | 1,224 | 4.74 | 5,802 |
| Washington | 9 | 127.00 | 312.00 | 89.00 | ..... | ..... | ..... | ..... |
| Wyoming | 5 | 210.00 | 456.00 | 8.00 | ..... | ..... | ..... | ..... |

In measurements of flowing water several units are in use, depending largely upon the amount of water and the connection in which the latter is discussed. For engineering purposes in the United States the unit most widely employed in measurements of rivers and streams is the second-foot, already described. The quantities of water discharged by artesian wells are, however, generally so small that the use of the second-foot as a unit is inconvenient on account of the fractions involved. The flow is therefore usually expressed in gallons per minute, the gallon being often employed by engineers in computations of municipal water supply. A cubic foot equals 7.48052 gallons, and therefore 1 cubic foot per second, or second-foot, equals 448.831 gallons per minute. Conversely, 1 gallon per minute is equivalent to 0.002228 second-foot.

The average discharge of the artesian wells, 54.43 gallons per minute, is equivalent to 0.121 second-foot. At this rate the flow from all the 8,097 wells was 979.74 second-feet. Comparing the average number of acres irrigated, viz, 13.21, with the average discharge of water, 0.121 second-foot, it appears that at this rate 1 second-foot would irrigate 109.17 acres. In other words, the duty of the water from these artesian wells under the assumptions made above was 109.17 acres per second-foot.

At an average expense of $245.58 per well, the discharge given cost at the rate of $4.51 per minute-gallon, or $2,025 per second-foot. Assuming that the duty of water as deduced above is 109.17 acres per second-foot, the average cost of irrigating an acre has been $18.55. As shown by Table 1, the average cost of irrigation throughout the entire country was $8.15 per acre, or 43.93 per cent of the cost by artesian wells in cases where these have been successful.

An artesian well discharging at the rate of one-tenth of a cubic foot per second, or 44.88 gallons per minute, will in one day cover an acre of ground with water to the depth of 0.198 foot, provided that none escapes by evaporation or seepage. Stating the same fact in another way, a well flowing at this rate will cover nearly two-tenths of an acre to the depth of 1 foot, and in a month of 30 days will cover 5.95 acres to a like depth. Thus, by storing the water, if it were possible to do so without loss, large quantities could be obtained from comparatively small wells. Unfortunately, however, the loss from ordinary earthern reservoirs is so great that

the smaller wells can hardly do more than saturate the ground in their immediate vicinity, little or no water accumulating on the surface unless this has been made almost completely impervious.

In most of the states and territories the area irrigated by flowing wells is almost insignificant; in the state of California alone does the ratio rise above 1 per cent.

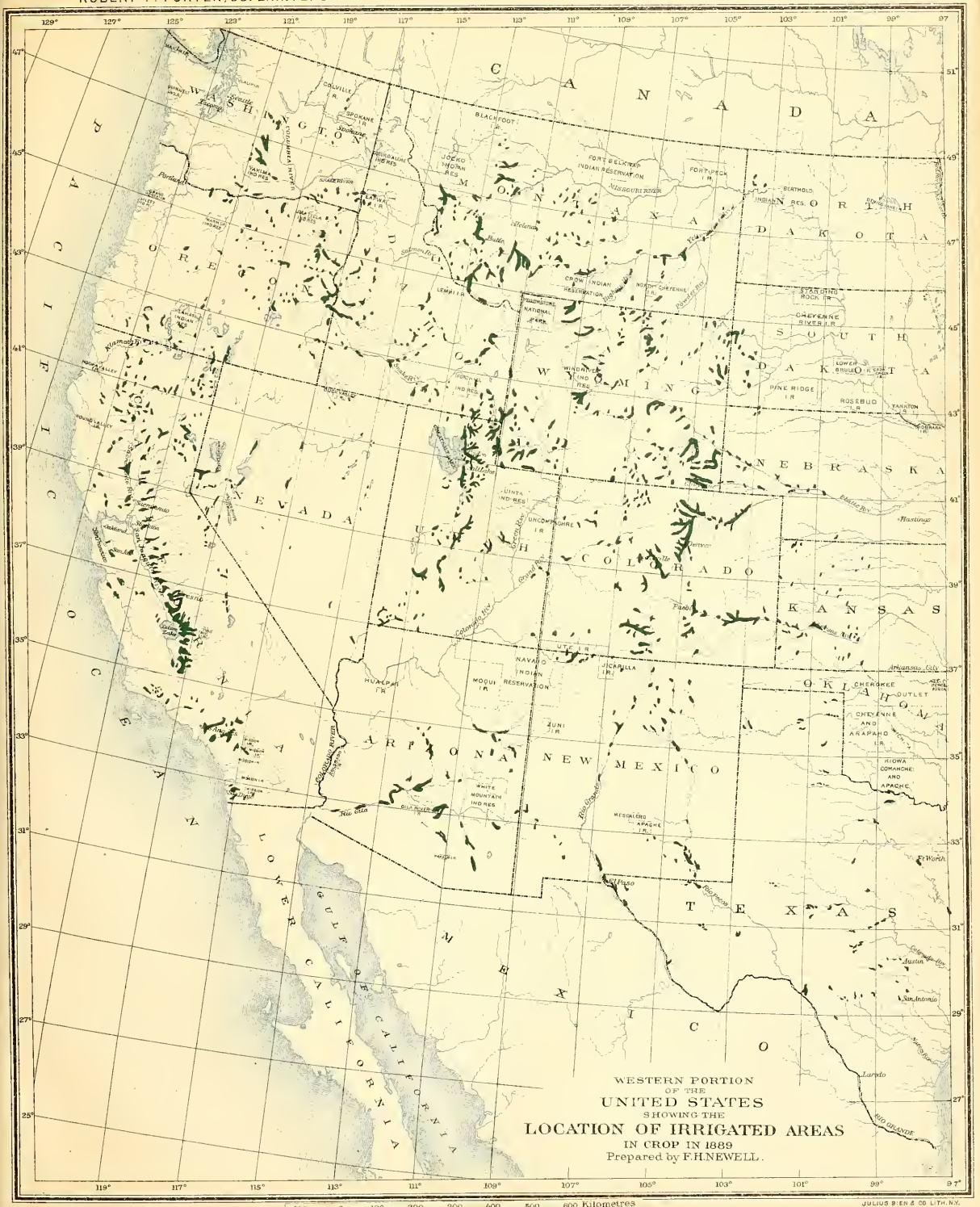
The following table shows the total area irrigated, as given in Table 1, the number of acres watered by artesian wells, as shown in Table 17, and the percentage:

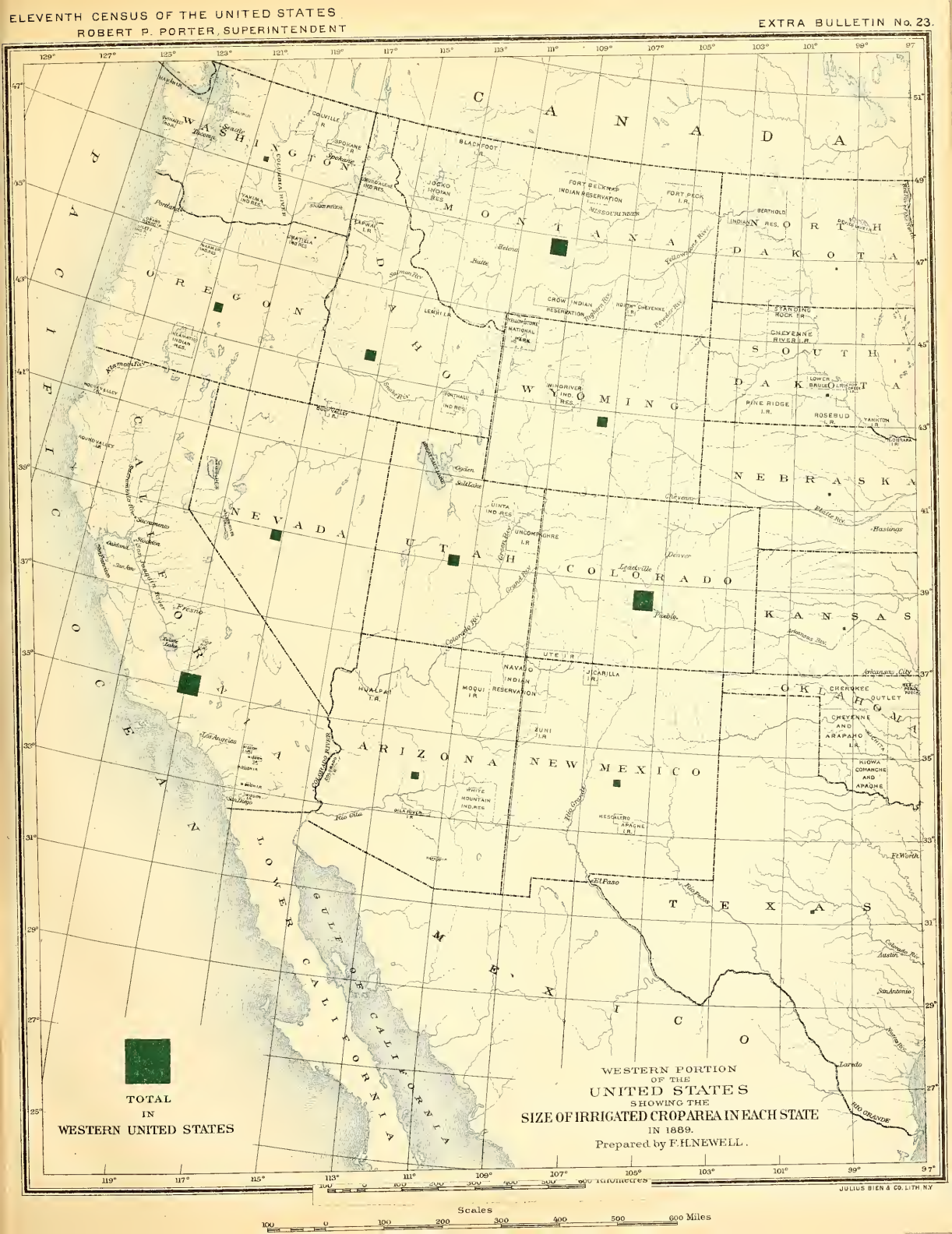
TABLE 18.—PERCENTAGE OF TOTAL AREA OF IRRIGATED LAND IRRIGATED BY WATER FROM ARTESIAN WELLS.

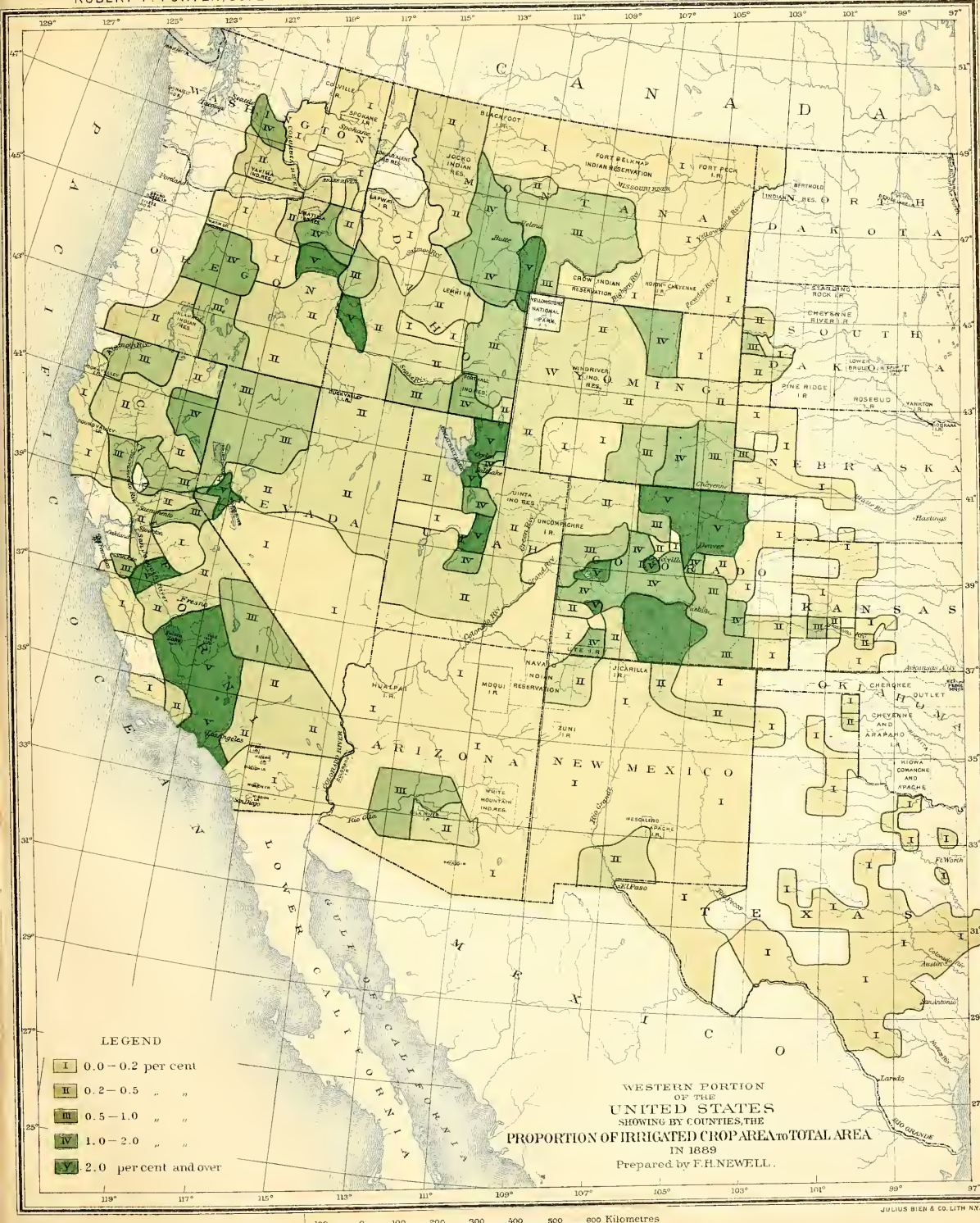
| STATES AND TERRITORIES. | Total area irrigated in 1889, in acres. | Area irrigated by artesian wells in 1889, in acres. | Per cent. |
|---|---|---|---|
| Total | 3,631,381 | 51,896 | 1.429 |
| Arizona | 65,821 | ..... | ..... |
| California | 1,004,233 | 38,378 | 3.822 |
| Colorado | 890,735 | 6,213 | 0.698 |
| Idaho | 217,005 | 185 | 0.085 |
| Kansas | 20,818 | 329 | 1.580 |
| Montana | 350,582 | 18 | 0.005 |
| Nebraska | 11,744 | 7 | 0.060 |
| Nevada | 224,403 | 20 | 0.009 |
| New Mexico | 91,745 | ..... | ..... |
| North Dakota | 445 | 20 | 4.494 |
| Oregon | 177,944 | 12 | 0.007 |
| South Dakota | 15,717 | 474 | 3.016 |
| Texas | 18,241 | 438 | 2.401 |
| Utah | 263,473 | 5,802 | 2.202 |
| Washington | 48,799 | ..... | ..... |
| Wyoming | 229,676 | ..... | ..... |

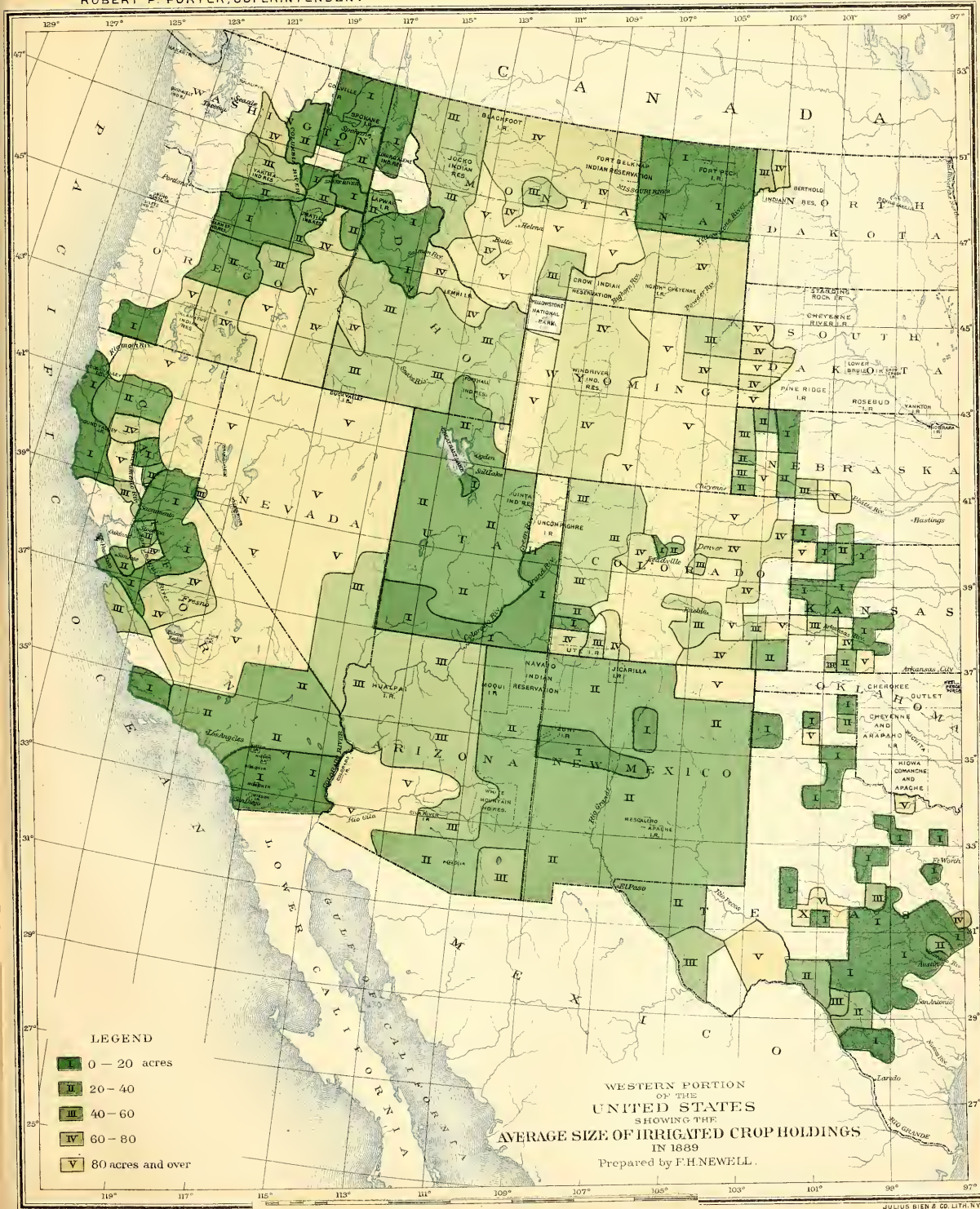
## BULLETINS UPON IRRIGATION.

The condition of irrigation and its relation to agriculture have been discussed in separate bulletins, one for each of the states and territories in which irrigation is practiced to any considerable extent. Bulletins have been issued for Arizona, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming, while those relating to California, Colorado, and the subhumid states are in course of preparation or printing. Reference should be made to these bulletins for the details of this method of agriculture within the several states and territories and for descriptions of the features of topography and water supply and their relation to agriculture in each county.


WESTERN PORTION
OF THE
UNITED STATES
SHOWING THE
LOCATION OF IRRIGATED AREAS
IN CROP IN 1889
Prepared by F.H.NEWELL.
Scales
100 0 100 200 300 400 500 600 Kilometres
100 0 100 200 300 400 500 600 Miles
JULIUS BIEN & CO. LITH. N.Y.


TOTAL
IN
WESTERN UNITED STATES
WESTERN PORTION
OF THE
UNITED STATES
SHOWING THE
SIZE OF IRRIGATED CROPAREA IN EACH STATE
IN 1889.
Prepared by F.H.NEWELL.
Scales
100 0 100 200 300 400 500 600 Miles
JULIUS BIEN & CO. LITH. N.Y.


LEGEND
I 0.0 – 0.2 per cent
II 0.2 – 0.5 " "
III 0.5 – 1.0 " "
IV 1.0 – 2.0 " "
V 2.0 per cent and over
WESTERN PORTION
OF THE
UNITED STATES
SHOWING BY COUNTIES, THE
PROPORTION OF IRRIGATED CROP AREA to TOTAL AREA
IN 1889
Prepared by F.H. NEWELL.
CANADA
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
COLORADO
WYOMING
IDAHO
OREGON
NEVADA
UTAH
ARIZONA
NEW MEXICO
TEXAS
OKLAHOMA
MEXICO
PACIFIC OCEAN
LOWER CALIFORNIA
GULF OF CALIFORNIA
100 0 100 200 300 400 500 600 Kilometres
100 0 100 200 300 400 500 600 Miles
JULIUS BIEN & CO. LITH. N.Y.

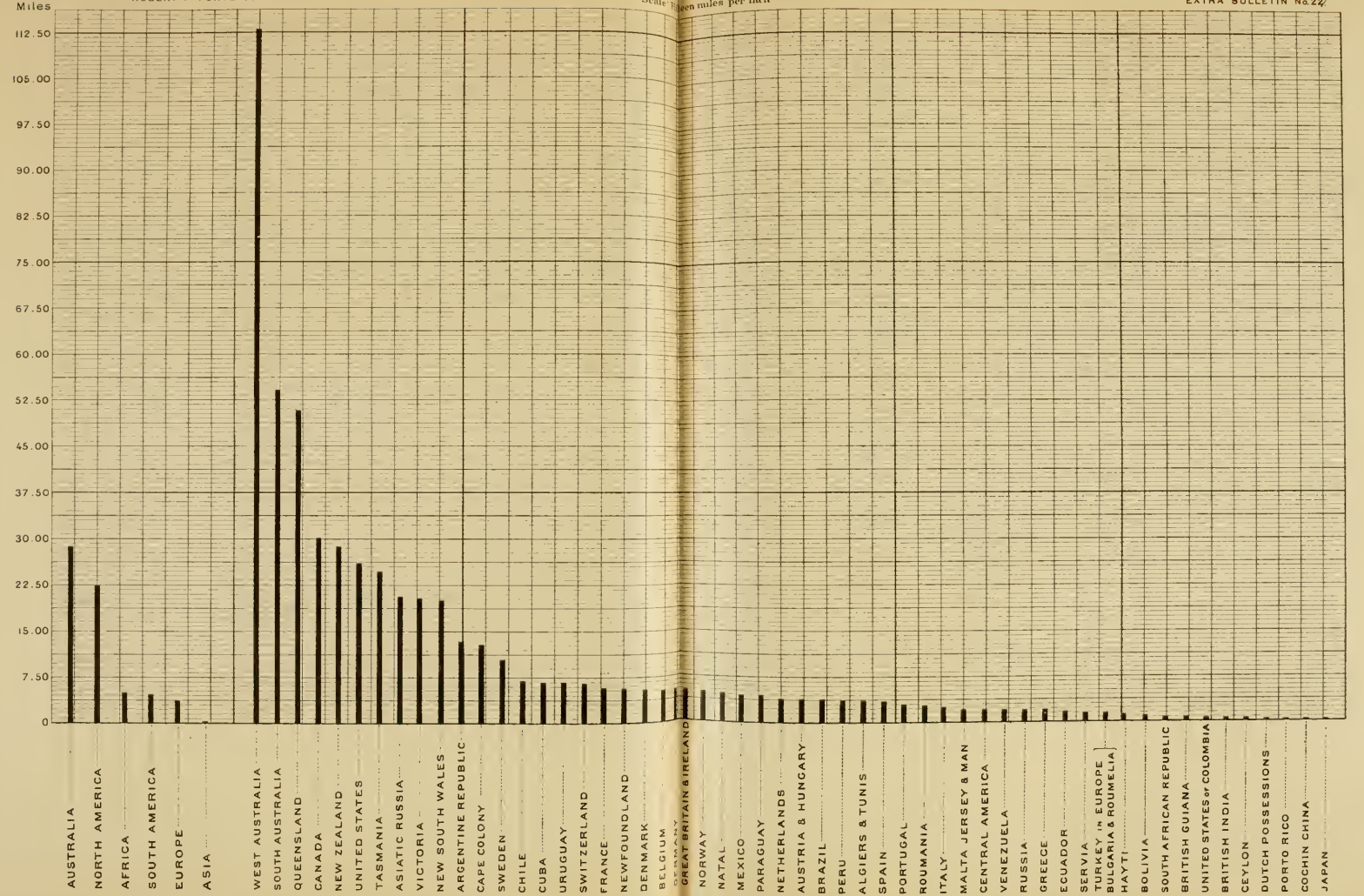

LEGEND
I 0 — 20 acres
II 20 — 40
III 40 — 60
IV 60 — 80
V 80 acres and over
WESTERN PORTION
OF THE
UNITED STATES
SHOWING THE
AVERAGE SIZE OF IRRIGATED CROP HOLDINGS
IN 1889
Prepared by F.H.NEWELL.
Scales
100 0 100 200 300 400 500 600 Kilometres
600 Miles
JULIUS BIEN & CO. LITH. N.Y.

# MILES OF RAILWAY
PER 10,000 INHABITANTS
IN
COUNTRIES.

ELEVENTH CENSUS OF THE UNITED STATES
ROBERT P. PORTER, SUPERINTENDENT

Scale—Seven miles per inch

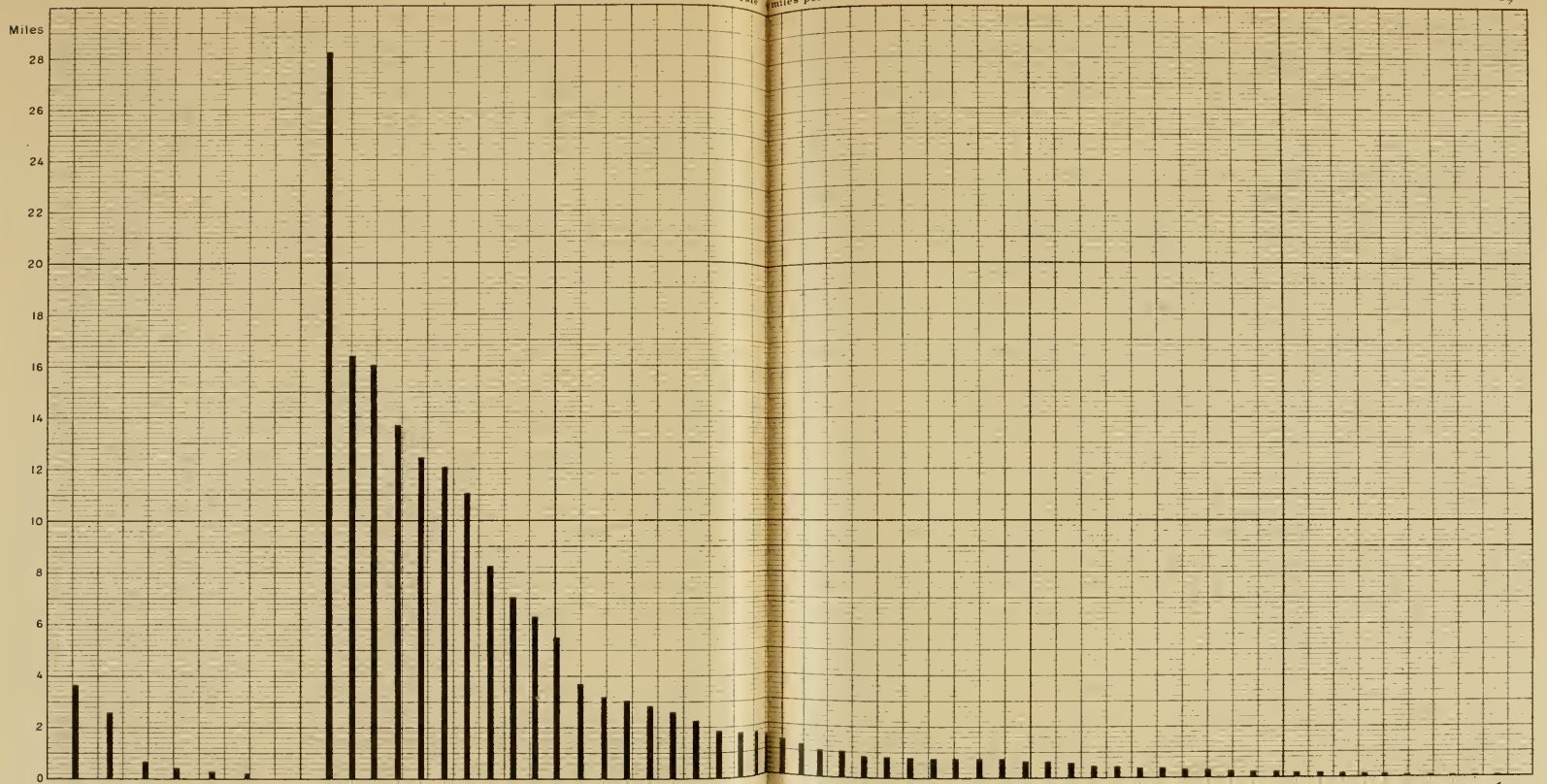




ELEVENTH CENSUS OF THE UNITED STATES
ROBERT P. PORTER, SUPERINTENDENT

# MILES OF RAILWAY
PER 100 SQUARE MILES
IN
# COUNTRIES.
Scale 1 mile per inch.



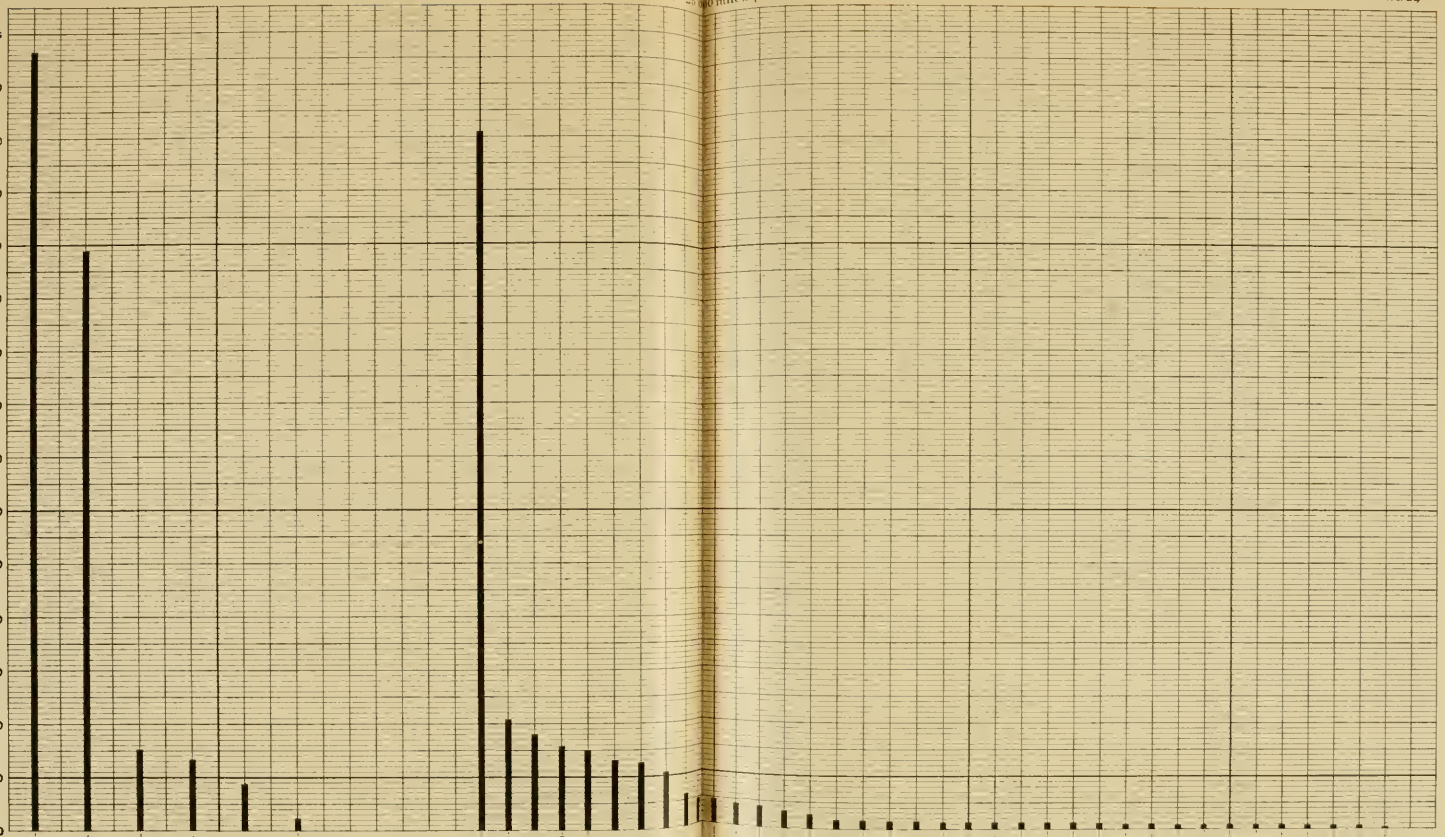


# RAILWAY MILEAGE OF THE WORLD
## FOR 1890
## COUNTRIES.

ELEVENTH CENSUS OF THE UNITED STATES
ROBERT P. PORTER SUPERINTENDENT

Scale 25,000 miles per inch

EXTRA BULLETIN No. 22




I
II
III
IV
V
VI
VII
VIII
IX
X
TERRITORIAL GROUPS
OF THE
UNITED STATES
ADOPTED BY THE
ELEVENTH CENSUS
FOR THE
COMPILATION OF RAILWAY STATISTICS
Scale
Scale
JULIUS BIEN & CO LITH NY

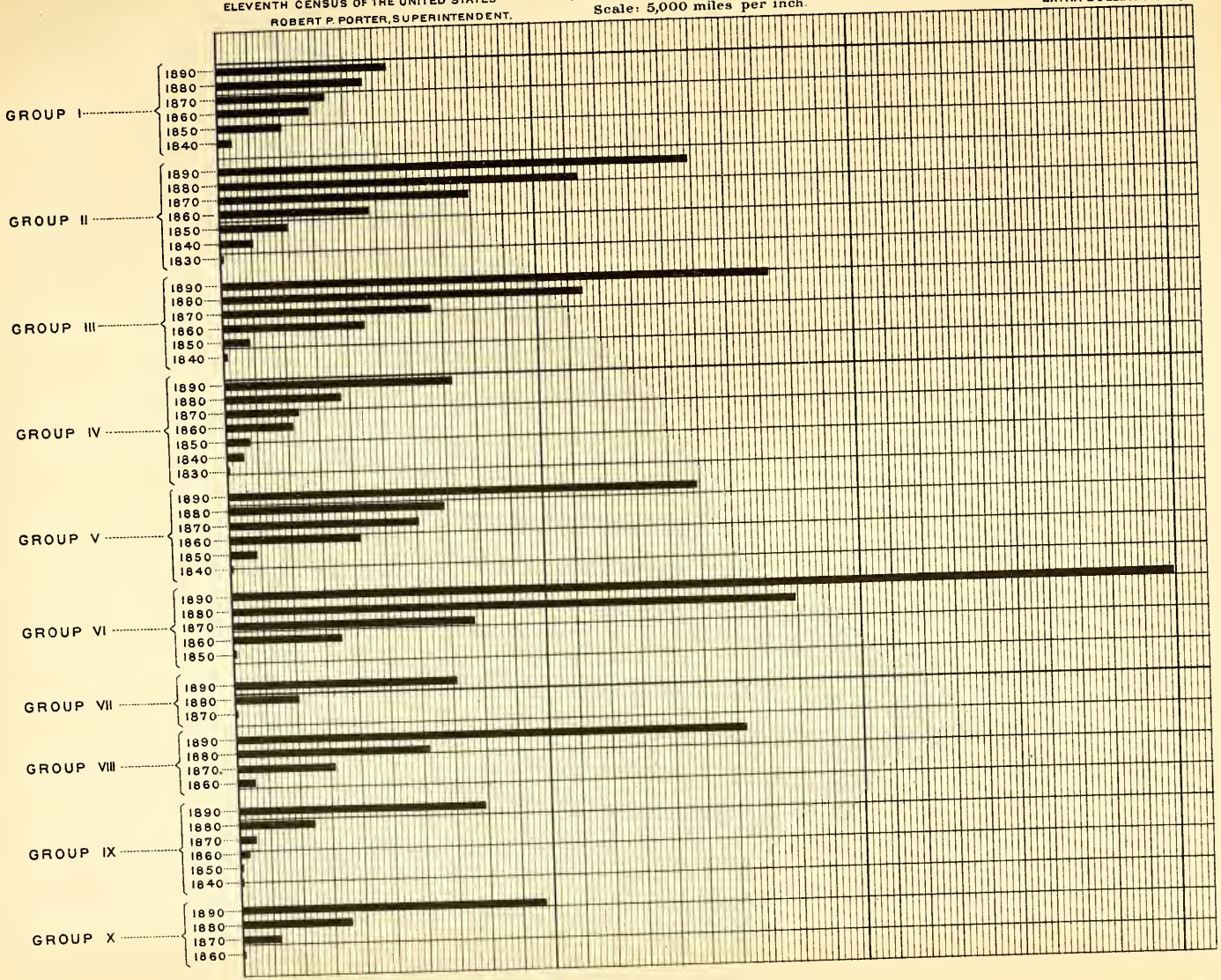
# RAILWAY MILEAGE OF THE UNITED STATES

## FOR THE CENSUS YEARS 1830 TO 1890, INCLUSIVE, BY TERRITORIAL GROUPS.

ELEVENTH CENSUS OF THE UNITED STATES
ROBERT P. PORTER, SUPERINTENDENT.

Scale: 5,000 miles per inch.

EXTRA BULLETIN No. 22.



# RAILWAY MILEAGE IN THE UNITED STATES

PER 100 SQUARE MILES OF TERRITORY

FOR THE CENSUS YEARS 1830 TO 1890, INCLUSIVE,

BY

TERRITORIAL GROUPS.

ELEVENTH CENSUS OF THE UNITED STATES

ROBERT P. PORTER, SUPERINTENDENT.

Scale: 3 miles per inch.

EXTRA BULLETIN No. 22

# RAILWAY MILEAGE IN THE UNITED STATES

PER 10,000 INHABITANTS

FOR THE CENSUS YEARS 1830 TO 1890, INCLUSIVE,

BY

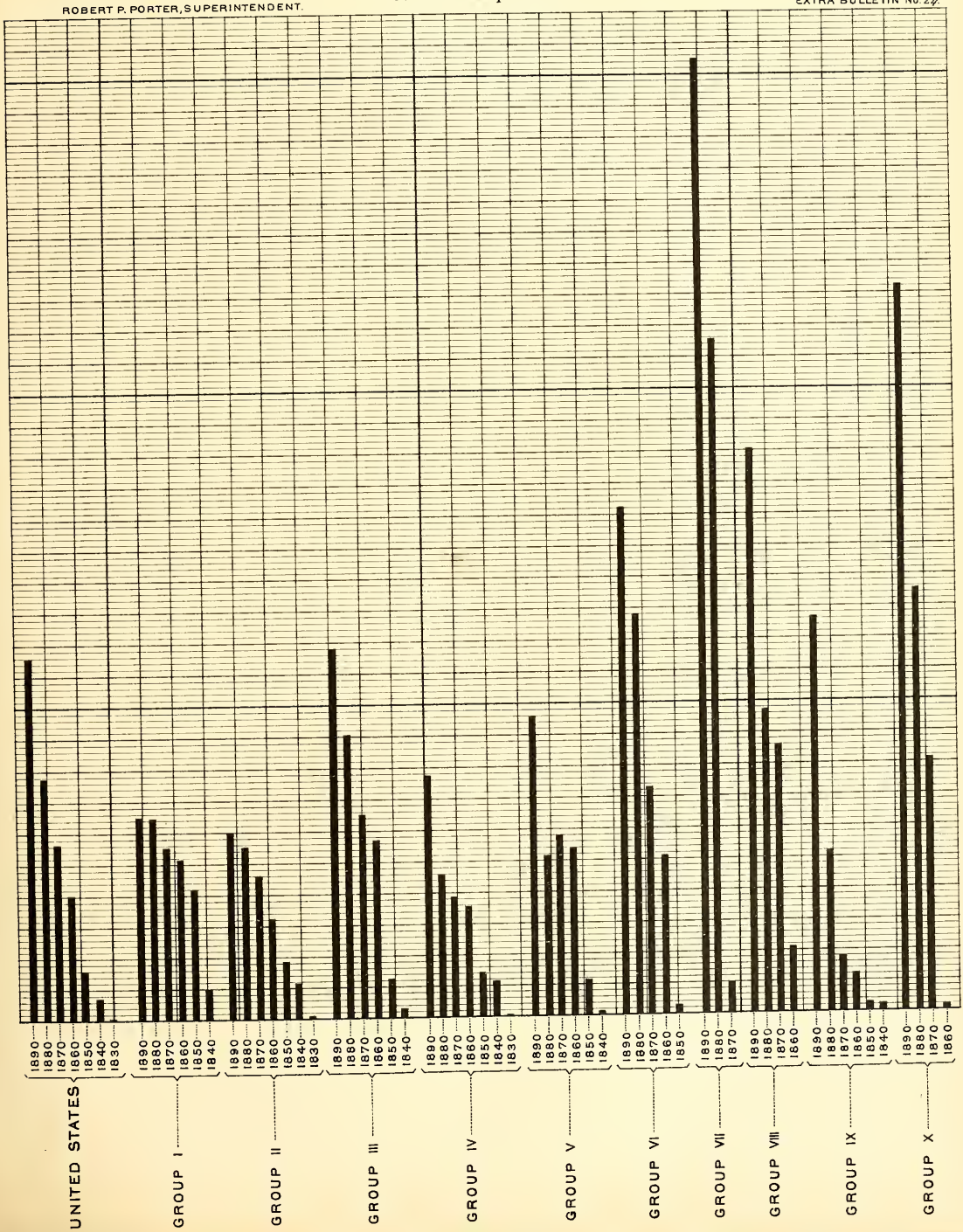
TERRITORIAL GROUPS.

ELEVENTH CENSUS OF THE UNITED STATES

ROBERT P. PORTER, SUPERINTENDENT.

Scale: 9 miles per inch.

EXTRA BULLETIN No. 27.



ELEVENTH CENSUS OF THE UNITED STATES
ROBERT P PORTER, SUPERINTENDENT

# RAILWAY MILEAGE OF THE UNITED STATES
## TERRITORIAL GROUPS.

Scale [illegible] miles per inch.

EXTRA BULLETIN No 22